RADIO and ELECTRONICS

ELECTRICITY — COMMUNICATIONS — SERVICE — SOUND

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MAGNETIC TAPE RECORDING

AMATEUR APPLICATION OF CRYSTAL DIODES

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OCTOBER 1st, 1950 VOL. 5, NO. 8 1/10

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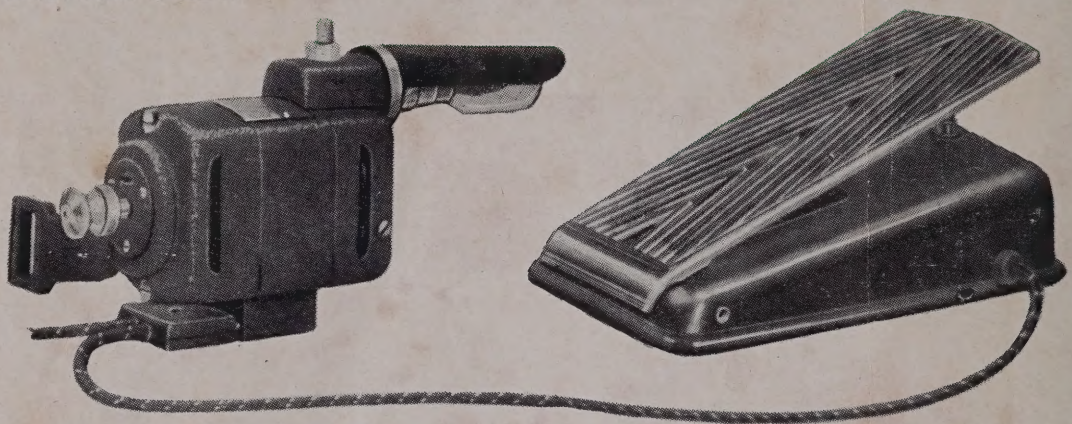

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OUR COVER

This rather striking photograph shows a fibre of special type of insulating paper used for making high-voltage condensers. The photograph was taken with an electron microscope at a magnification of 6000 times. The makers of the microscope, Messrs. Philips, Eindhoven, Holland, state that this is "comparatively small," but that, as can be seen, the resolving power is particularly high.

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GUY E. MILNE
ELECTRONIC TECHNICIAN

TELEVISION FOR THE AMATEUR

In our September issue, an editorial article appeared entitled "Television and the Amateur." Readers may be surprised to note that this month's title is almost identical—but not quite. It heralds, not the fact that experimental television circuits suitable for amateur use could be devised, but that this Journal has decided this the time is ripe for some work to be done along these lines, and that commencing in an early issue, some simple gear will be described, that will actually produce an image on the face of a cathode ray tube. This equipment is, of course, designed more particularly for amateur transmitters, but there is no reason why anyone interested should not build it, since there is no legislation against the production of images on a tube as long as no radio transmission is indulged in!

Some little time ago, the writer was chatting with an amateur transmitter of several years' standing, who asked, in effect, where "ham" radio was going from here. "We have," he said, "transmitted on 80 metres, with key and mike, and we have worked DX with a multitude of countries. We have done the same thing on 40, 20, and 10, not to mention 6, and we have nattered locally on one or another of these bands for years. Now we're starting to natter on the very high frequencies, too, but once you've built the gear the procedure is just the same as it was years ago. So what are we going to do that's new? It looks as if we'll have to wait for television."

A good many amateurs will probably disagree with the attitude shown by our friend, but there are probably a good many, too, who would welcome something quite new in the way of something to experiment with. Television as a public service is on the way in Australia, and overseas publications reflect the tremendous interest in it in Britain and America. We do not know yet what will happen here, but as we have said before, there is no reason why the amateur should not start to take a practical interest, if some means can be found of circumventing the problems of expense and equipment.

After giving the matter considerable thought, we have come to the conclusion that owing to our own peculiar circumstances, these major difficulties are by no means insurmountable, and that to make a start now would not be outside the bounds of possibility.

It has been decided, therefore, to institute the "R. and E. Amateur Television Project" forthwith, and indeed some of the required laboratory work has already been undertaken. Now, there are a number of ways in which a project like this could be tackled. One would be to draw up the plan of action, do the necessary developmental work, and when this was satisfactorily completed, burst into print with the whole story as a *fait accompli*. This would be all very well, but while all the experimental work was going on, no one but ourselves would have the interesting part of the job—namely making the gear work. With techniques that are bound to be very new and strange to many readers, it would be better, we consider, to tackle the matter in a different way altogether.

In the first place, the plan of action must still be drawn up, and development work must still be carried out. But the work will divide itself into a number of more or less watertight compartments, each with its own set of problems which can be met, solved, and then stored up while another compartment is being dealt with. Jobs like this are not easy, though, and a number of difficulties can be foreseen, but from the point of view of those who will want to duplicate the work for themselves, and in the process learn something of the practical side of television technique, it would be much better, we think, if we break up the whole project into its component parts, and describe each one, and its particular problems as they crop up, and as they are solved.

By doing things in this way, the reader would virtually be brought into the laboratory with us. He would know what the difficulties are before they have been met, and would be able to follow the progress of the work just as if he were here engaged on the project with us. By the time he has followed us through our development of the equipment, he would know as much as we have found out ourselves, and this is always considerably more than can be put into an ordinary article after the work has been completed.

What, then, are we to tackle? First of all, the production of images of still transparencies. This will be attempted by the flying spot scanning method, and in principle, the gear will be identical to that used by television stations to generate video signals from moving picture film. This will constitute the first part of the project, and a very important one it is. The great advantage of it is that it enables a video signal to be produced without the possession of a special camera tube—iconoscope, emitron, image dissector,, or what have you. And it will be possible to get results of some sort using ordinary cathode ray tubes—as for example, the 5BPIs so many of which have been bought for a song from war assets stock. One of the things that cannot yet be foreseen is the actual picture quality it will be possible to get in this way. If things were available here that unfortunately are not, the ideal would be to use white-screen magnetically deflected picture tubes such as are used in television receivers, and there is no doubt at all that picture quality comparable with standard television reception could be obtained in this way. But the idea is to see just what we can do with our own limited resources. But that is looking ahead a little. Not too far, however, for we hope publish the first of our series of articles on the "R. & E. Amateur TV Project" in the November issue of this journal.

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Some Practical Tests of a "Scott" Dynamic Noise Suppressor

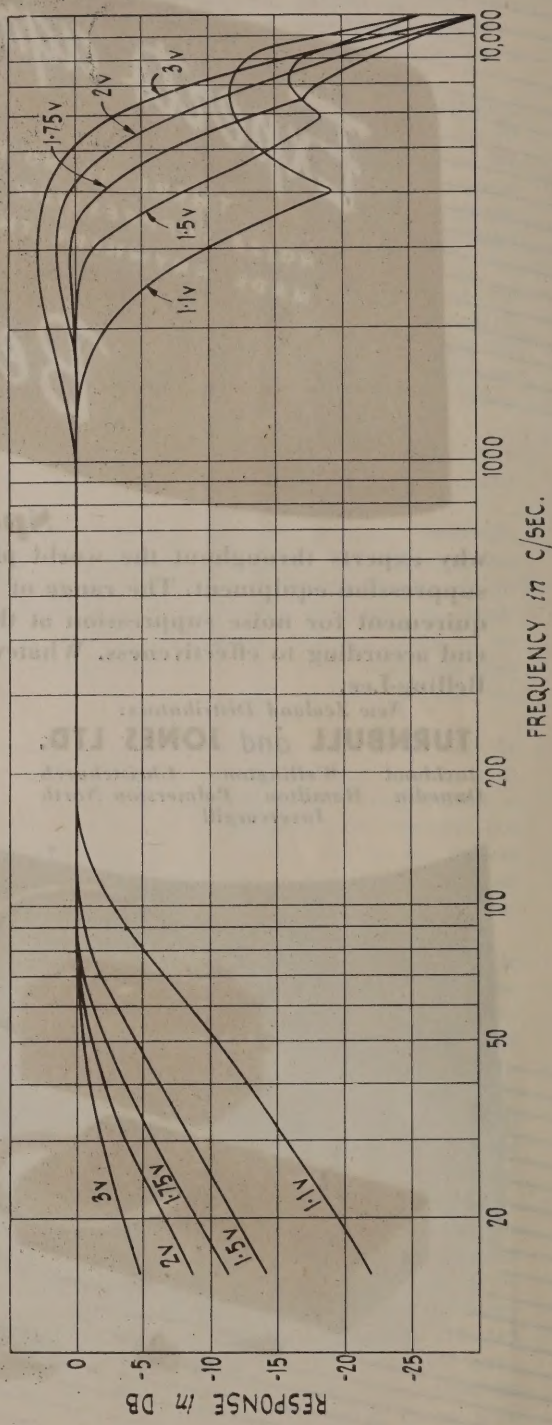
Several months ago we published two articles about the Scott Dynamic Noise Suppressor, including a full circuit, as recommended by the originator for use in home radio-gramophones. This short article describes our own reactions to the working of the device in practice, and gives performance curves, which will be found on this page.

INTRODUCTION

Since the dynamic noise suppressor was described in these pages, at least one firm has advertised suitable audio frequency chokes, which enable the average constructor without laboratory facilities, to build the circuit and give it a trial. We ourselves had not built one, but were fortunate recently in having one lent to us by a reader, who had purchased the commercial chokes, and had built up the circuit. While it was in our possession, we took the opportunity to give it a thorough 'go over," and to listen to a variety of records through it, and the present short article is presented as the result of these observations, since it was thought that a considerable number of readers would be interested in hearing about its actual performance in practice.

RESPONSE CURVES

The circuit is rather a difficult one on which to draw performance curves, and there are a number of traps for the unwary. For instance, it is not possible to apply an input voltage of variable frequency, and thus draw a response curve that has any meaning in relation to the actual performance. This is because the frequency response at any instant varies, not only with the amplitude of the input voltage, but also with the frequency of that voltage. It will be remembered that the high-frequency "gate," or control circuit, is sensitive to the frequency of the input voltage, in such a way that low frequencies have no effect on it. It starts work only after a certain frequency has been reached, so that if the test oscillator's frequency is gradually increased, while set to a certain amplitude, the gate will open only during the time when the oscillator is within the medium/high range. The high frequencies themselves do not open the gate, so that if the oscillator is run through the audio stage, the gate will not be open when the high-frequency signals are present, and the object of the frequency run is defeated. Thus, the only way in which response curves can be drawn is to disable the automatically-worked gate circuit, and open it by means of a D.C. bias applied to the reactance tube. Thus, in order to take the response curves that appear on this page, the following procedure was adopted. The grid circuits of the reactance tubes were disconnected from the outputs of their respective control rectifiers, and a known value of D.C. bias was placed on their grids. For each value of bias, the audio oscillator was run through the range, and a response curve drawn. We thus get a series of response curves representing the behaviour of the amplifier under different conditions of opening or closing of the gates. Even this process does not give a true picture of what happens when the thing is used, because in practice, the signal itself opens the gates, and whether a gate is open or not depends on the signal *frequency*



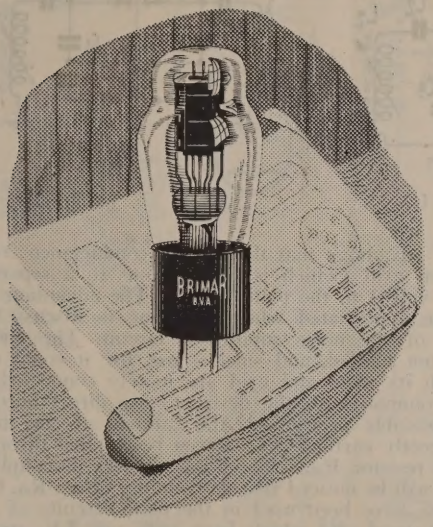
as well as on its amplitude. However, it does present a visual picture of what goes on, and how well the gates do open and close, as well as telling us what the full extent of their opening and closing is.

It should be remembered, too, that the gates, for low and high frequencies respectively, are not necessarily open by the same amounts at the same time, as the curves would tend to imply. They act quite independently of each other.

COMMENTS ON THE CURVES

The first thing to strike the observer is that without any control voltages applied to the reactance tubes, and therefore with the gates closed, the frequency response of the system is particularly narrow, being 3 db. down at only just over 2000 c/sec. On the graph, this has been marked as 1.1 volts. One might have expected to see this curve labelled 0 volts, indicating that no control voltage existed. However, it was found that with no input signal, the diode contact potential gave an initial bias to the reactance tubes of —1.1 volts. Thus, in order to simulate the conditions where the circuit is acting normally, but without enough input voltage to work the gates at all, it was necessary to put this amount of D.C. bias on the reactance tubes. It will also be noticed that the curve which gives the widest response is labelled 3 volts. This is because any further control voltage had no further effect on the response curve. From this, then, we can say that a control voltage of 1.9 volts D.C. is sufficient to open the gates fully. This is important, because it gives a clue as to the signal amplitude necessary to work the gates. Assuming that the control rectifier is 100 per cent. efficient (it will be nearly so) an A.F. signal of only 1.2 volts R.M.S. at the plate of the diode will be enough to operate the control fully, while considerably less than this will give a noticeable effect. It can be seen, therefore, that not a great deal of amplification is needed to make the suppressor work

(Continued on Page 47.)



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The "R. and E." Senior Communications Receiver

PART II

In the first instalment of this article, printed in last month's issue of Radio and Electronics, *the line-up of the receiver was described and a block diagram shown, giving the general arrangement of the fifteen valves used in the I.F. unit. This month, the circuit is described in detail from the input terminal to the beginning of the audio amplifier.*

CIRCUIT DETAILS

The circuit presented here commences with the 455 kc/sec. input from the tuner, and finishes at the input to the audio amplifier. This has been done, partly as a matter of convenience, in order to avoid an over-large circuit diagram, and partly because many readers will no doubt wish to build only the I.F. section, and make use of an existing power supply and audio amplifier. The A.F. section, and the power supply will, therefore, be given in a later instalment, as a separate circuit diagram. In order to make the present circuit easier to follow, the valve numbering has been done in accordance with the numbering on the block diagram. V_1, in the centre block, is the input stage, and is thus a 455 kc/sec. amplifier. In the grid circuit of this valve, which is an ECH21 triode-heptode, is a 455 kc/sec. tuned circuit comprising L_1, and C_{18}, C_{19}, and C_{20}. The latter is merely the usual bypass condenser which allows A.V.C. voltage to be fed to the grid. C_{18} and C_{19} in series tune the coil, and at the same time make a capacitance voltage divider in order to provide a low-impedance input terminal. This is connected to their junction. C_{18} is the normal 100 $\mu\mu$f. fixed condenser that is supplied with the coil (a shielded unit) while C_{19} is 0.001 μf. As an input matching device, this circuit is very effective, but is seldom seen. At the output of the tuner, which ends up with an oscillator-mixer valve, we have exactly the same thing in reverse, so that in this case, the capacitative voltage divider steps the output down to a low impedance, while the one on the input of the I.F. section, depicted here, steps up this low impedance again for the grid of the first amplifier tube. The scheme is very efficient, with losses little if at all greater than those in a conventional I.F. transformer. It will be recognized that the two 0.001 μf. condensers are in parallel when the two units are actually connected by the cable, and that the whole arrangement is simply an application of the so-called bottom-capacity-coupling between two tuned circuits. Here we make use of the fact that when this coupling system is used, the R.F. voltage on the coupling condenser is low, and so also is the impedance, which enables a long connecting cable to be used if necessary, without its capacity having any harmful effect. This capacity simply adds itself to the capacity of C_{19} and the other similar condenser at the other end of the cable, and thus has a negligible effect on the tuning of the coils. When the units are connected together, and the coils adjusted to frequency, the cable capacity is automatically "tuned out," and because it has 0.002 μf. in parallel with it, the cable capacity can be quite large, and the only effect it will have will be a small alteration in the co-efficient of coupling between the tuned circuits. In short, this is an excellent scheme for any application where R.F. or I.F. has to be sent over a length of connecting cable. It has also been used in some car radio sets in which the tuner is separate from the I.F. and audio circuits. As with all the other 455 kc/sec. circuits in this receiver, the input coil is permeability-tuned.

Readers will no doubt be wondering why a triode-heptode has been used in this amplifier stage, with the triode section unused, instead of an ordinary R.F. pentode. The reason is to be found in the fact that a Lamb noise suppressor was wanted, and this circuit requires a valve with two control grids. The 6L7 answers to this description, but is unfortunately not available today in any quantity. The only other valve that was thought to be really suitable was the ECH21, and accordingly, this valve was used. The heptode section makes an excellent I.F. amplifier under any conditions, and it has

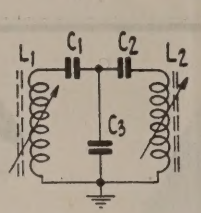


Fig. 1

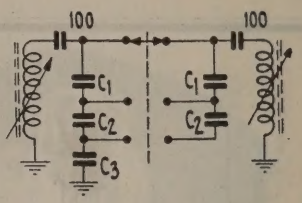
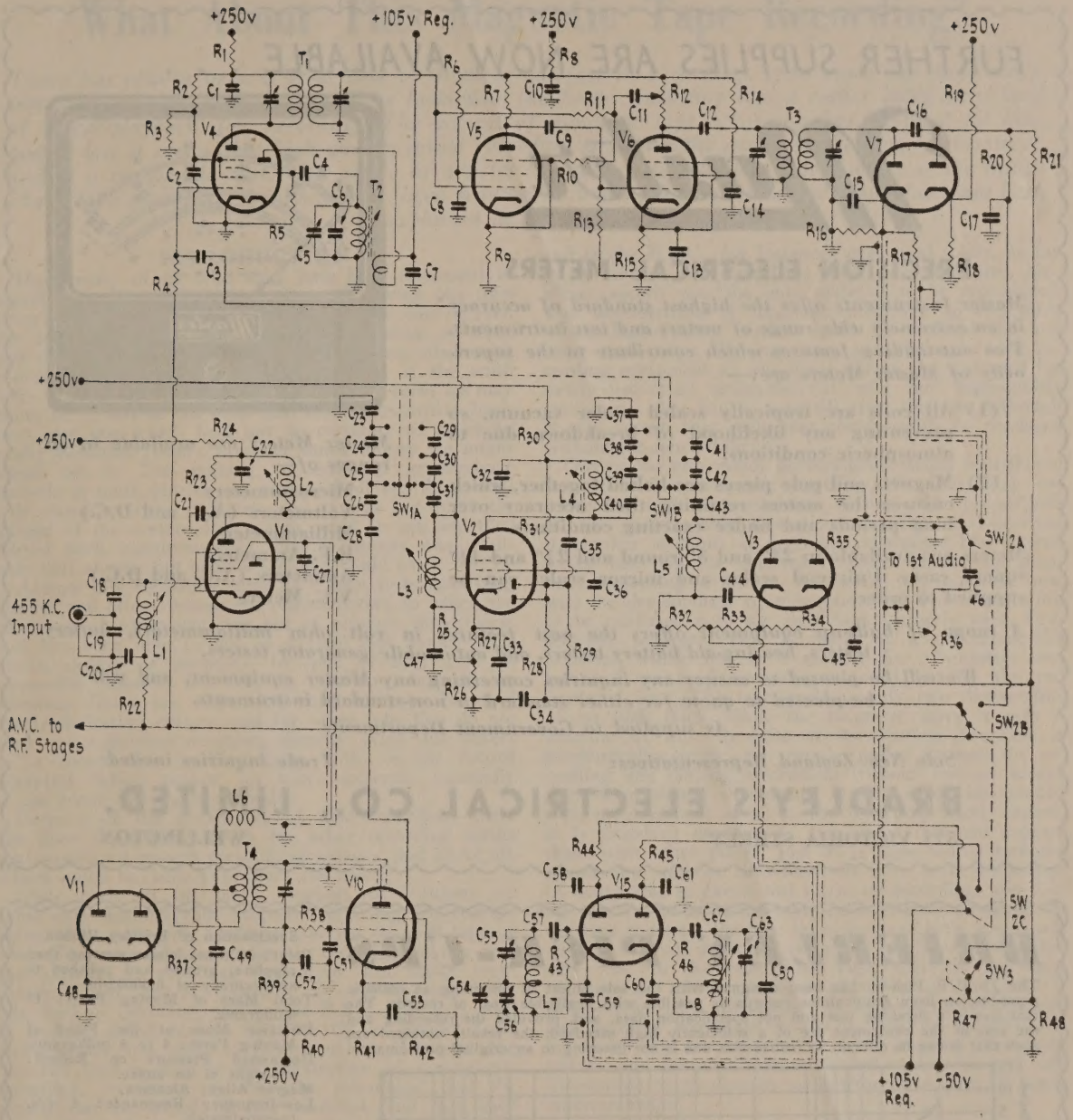


Fig. 2

the further advantage that the mutual conductance from the injection grid (which is brought out to a separate pin in this valve) to the plate is high. The advantage of this will be appreciated when we come to discuss the application of the noise suppressor circuit. The triode section is not needed, and since a use for it could not be invented, its plate and grid are merely connected to earth. In common with the desire to use direct biasing wherever possible in the set, the cathode of this first stage is directly earthed. The screen is supplied through a dropping resistor R_{23}, while R_{24} is an I.F. de-coupling resistor. It will be noticed that de-coupling filters R_{24}, C_{22}, and R_{30}, C_{32}, have been used in the plate circuits of V_1 and V_2. In most sets which have only one I.F. stage, this filter can safely be omitted, but it is essential to include them wherever more than one stage is tuned to the same frequency.

As was mentioned earlier, the 455 kc/sec. channel is provided with variable selectivity in the form of a three-position switch. This is Sw_{1A} and Sw_{1B} on the diagram, and the first section varies the coupling between L_2 and L_3, the tuning coils for the plate of V_1 and the grid of V_2 respectively. These coils, like L_1, are individually shielded, each in its own can, and are each provided with a 100 $\mu\mu$f. fixed tuning condenser. These condensers are C_{26} and C_{31}. The selectivity switch is shown in the "broad" position, and it can be seen that C_{29} and C_{30} are out of circuit, while the switch bridges C_{26} and C_{31}. Now, although this coupling circuit looks quite complicated, even with C_{29} and C_{30} out of consideration, it really boils down to a simple arrangement of three condensers. C_{26} and C_{31} and two of these, while the third is made up of C_{25}, C_{24}, and C_{23}, all in series. C_{28} can be left out of consideration, as it is merely a blocking condenser, coupling output from V_1 to the input of V_{10}. This system of three condensers is again our old friend "bottom-capacity-coupling," in yet a new guise. In case

(Continued on Page 36.)



Note:—Only the identity of the main components is shown below to aid readers in following the explanation in the text. Full circuit values will be given in a later instalment of the article.

V_1, ECH21.
V_2, 6AR7-GT
V_3, V_7, V_{11}, 6H6
V_4, X61M
V_5, V_6, 6SG7
V_{10}, 6BA6
V_{15}, 6SN7-GT
Sw_1, 455 kc/sec. selectivity switch.
Sk_2, 455–100 kc/sec. change-over.
Sw_3, A.V.C./Manual change-over.
R_{41}, noise suppressor threshold.
R_{42}, 100 kc/sec. selectivity.
R_{47}, manual gain.
R_{39}, A.F. gain.
L_1, L_2, L_3, L_4, L_5, single 455 kc/sec. coils in cans.
L_6, 10 mH. R.F. choke.
L_7, L_8, B.F.O. coils, 100 and 455 kc/sec. respectively.
T_1, T_3, 100 kc/sec. I.F. transformers.
T_2, 355 kc/sec. osc. coil.
T_4, 455 kc/sec. Xtal filter input Xformer, used as noise rectifier transformer.
C_5, fine tuning for 100 kc/sec. channel.
C_{34}, 100 kc/sec. B.F.O. tuning.
C_{63}, 455 kc/sec. B.F.O. tuning.

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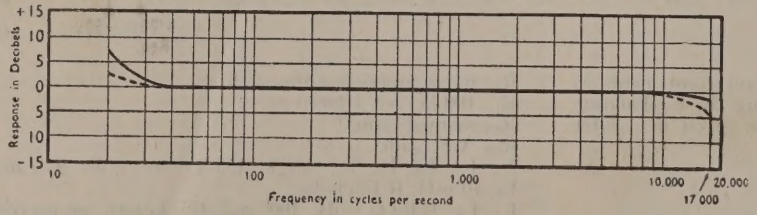

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What About This Magnetic Tape Recording?

There has always been a great deal of amateur interest in recording, even since the days when virtually the only kind that could be tackled in the home workshop was a rather indifferent kind of direct-playback disc recording. The advent of magnetic tape recording has changed all this, and at last it seems that high-quality sound recording is within the grasp of the man-in-the-street, and at a reasonable cost. This series of articles is designed to tell our readers many of the things about tape recording that they have been wanting to know for some time, but which have not been explained in the popular press.

INTRODUCTION

How many of us who have long been interested in sound reproduction have had ideas of making our own records? And how many have looked at the cost of even the least expensive equipment for recording on disc, and shuddered, thereafter to give up the idea, albeit with considerable regret? Practically all of us, if the truth were known. Sound recording, in whatever form we may think of it, has in the past been a most expensive business, and one which held out no certainty of attaining really excellent results, however much money we might spend on it. The making of ordinary gramophone records is quite outside the scope of all but those with full manufacturing facilities, and it was not until the advent of the acetate disc, which could be cut, and then played back instantaneously, that a process was available that anyone but a manufacturer could use.

Acetate disc recording came as a boon to broadcasting studios and other commercial organizations, to which the first cost of equipment was not of primary importance, and has been able to act as a time and money-saver for a variety of purposes. In spite of this, it is an expensive business, not only in first cost, but also in running. Discs are expensive, and have to be used freely in testing cutters, and for other jobs that do not turn out a finished recording directly. Also, any defect on a record has to be put up with, or the record scrapped, which makes for more expense, especially if one wants only the best results.

Because of the drawbacks of disc recording, there has been a constant search for other recording media that would not possess these disadvantages, and above all, which would be cheap to produce and use.

Quite early in the piece, Poulsen, of Poulsen arc fame experimented with magnetic recording, his records being made with only moderate success on steel tape or wire. Thus, the idea of magnetic recording is not new nor even is its practical application. For many years before World War II, recording on steel tape was actually used in Germany, and by the B.B.C. The very idea of making sound records magnetically, as distinct from mechanically, has much to recommend it. Whatever the material that is used in the production of a magnetic recording, we have at once the advantage that the record can be wiped off the material, and this used again. Even if the material is expensive, therefore, its use must be economical, because records of a temporary nature can be made, used, and destroyed, without using up any of the material. And because of the phenomenon of permanent magnetism, the same system can be made to yield permanent records that can be kept as long as we please.

Early magnetic recording systems made use of thin steel tape, magnetized during the making of the record, and demagnetized in order to remove the record and make the tape available for use once more. Unfortunately, these systems did not gain much popularity because of their poor reproduced quality. They were not really good enough for the reproduction of music, and at the B.B.C., for instance, were used solely, as far as is known, for recording talks, news bulletins, etc., where speech was the only material to be reproduced. The development of magnetic recording to the pitch where high-fidelity results could be realized did not come until after the last war, and although such recording equipment as was made during the war used the newly-discovered principles, it was not high-quality equipment; that had to wait till after the war, although it was known that such gear could readily be produced without too much difficulty.

One of the two major developments which contributed towards making magnetic recording what it is today was concerned with the reduction to negligible proportions of the objectionable distortion that had characterized the earlier attempts at magnetic recording. The second, which has had the noteworthy effect of making magnetic recording available for home and amateur use, was the development of magnetic tape. This tape is not to be confused with the steel tape formerly used. Present-day magnetic tape is made of a cellophane-like material, which acts as a support for a minutely thin layer of powered magnetic material, mainly the red oxide of iron. The tape itself is only two thousandths of an inch thick, while the magnetic layer is only a fraction of this. In spite of its thinness, the tape is mechanically strong, and can be pulled through the recording and playing mechanism without fear of breakage. Even should this occur, it may easily be mended with no detriment at all to the recording itself. Indeed, it is standard practice to cut pieces out and replace them with other pieces, just as is done with cinematograph film, and we thus have the very great advantage of being able to excise bad pieces of recording, and join up records made at different times. Again owing to its extreme thinness, the tape takes up very little room, and enough for half an hour's recording can be kept on a reel only 7 in. in diameter. This tape, then, is the ideal medium for non-professional recording of all sorts. It can be used as a dictaphone, or to record conversations and business meetings: it can be used to record commentaries for otherwise silent films, making them into talkies, and for an almost unlimited variety of purposes in addition to its obvious application as a form of home entertainment.

PRINCIPLES OF MAGNETIC RECORDING

Before commencing to describe basic principles, it might be as well to mention wire recording, and indicate why we are apparently leaving this type out of consideration. The reason is that for many purposes, wire recorders are not nearly so suitable as tape recorders, and it looks as though for home use, the tape will come more and more into use at the expense of wire. However, most of the remarks applicable to tape recording can be referred to wire recording also, since the principles are identical, and the main differences between the two systems are mechanical ones, which need not concern us.

In order to understand the process of recording and playing back from tape records, it is necessary to go into the basic mechanism of magnetism to some extent. We have already seen that the tape consists of a magnetically inert carrier (the cellophane or other tape) on which is deposited a thin layer of magnetic material which carries the recording. This material is very finely divided, the individual pieces being only about a thousandth of a millimetre across. In an actual machine,

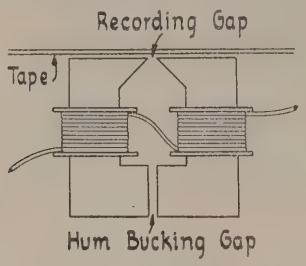

FIG. 1

the tape is arranged to move at a constant speed past the recording head. This is constructed much as in Fig. 1, and consists of a magnetic core, usually of mumetal laminations, provided with two or more coils through which audio frequency currents can be passed by connecting them to the output of the recording amplifier. In the core are two gaps, one of which is as close as possible to the tape, and is usually in contact with it as moves past, and the other at the opposite side of the core, remote from the tape. These gaps are very small—only about two thousandths of an inch across—but wide enough for a magnetic field to be produced external to the iron core. Now, any alternating current that is passed through the coils of the recording head causes an alternating magnetic flux to develop across the gap in the core, and the tape is so placed in its passage past the head that it is subjected to this magnetic field. By an alternating magnetic field, is meant that the direction of the field alternates, just as does the direction of the current flow through the coils. For instance, during one half-cycle of the alternating currrent through the coils, the core will be magnetized so that the left-hand pole of the gap is North, while the right-hand pole is South. During the remaining half-cycle of A.C., the polarity of the core's magnetization will be reversed, making the left-hand pole South, and the right-hand pole North. Now let us see what happens to the tape while one cycle of A.C. passes through the coils. When the current is zero, at the start of the cycle, there will be no magnetizing force, and the bit of tape that is momentarily opposite the gap in the core will be unmagnetized. However, as the current starts to flow and increases in accordance with the sinusoidal wave-shape of the A.C., so the magnetizing force commences and increases in proportion. Therefore, at any instant, the piece of tape over the gap is subjected to this increasing magnetizing force, and becomes magnetized accordingly. At the peak of the half-cycle, the current and therefore the magnetizing force is at maximum, so that the bit of tape opposite the gap at this moment has a maximum degree of magnetization imposed upon it. During the remainder of the half-cycle, the current, and therefore the tape's magnetization decreases until where the current cuts the zero axis, both it and the magnetization are zero again. Now the current starts to flow in the opposite direction, and the other half-cycle of A.C. takes place, producing corresponding degrees of magnetization in the tape, but in the opposite direction. That is to say, during the first half-cycle, the strength of the magnetization varied in accordance with the current, but the polarity throughout was the same, say with the left-hand pole of the core North and the right-hand pole South. During the second half-cycle, the same variation of magnetization is caused, but now that the direction of current flow has reversed, the left-hand pole is now South, and the right-hand one North.

If we like, we can visualize the process as follows.

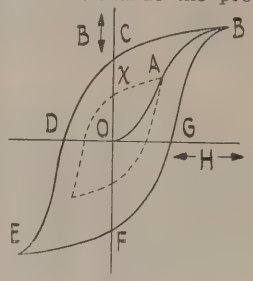

FIG. 2

During any instant, the small length of tape that covers the gap becomes a small bar magnet. Its polarity depends on what half of the A.C. input cycle is in progress at the time, and its strength depends on what part of that half-cycle the instant we are considering represents. After recording, then, the tape's length becomes a series of small bar magnets, end to end, each one representing in strength and polarity the strength and direction of the current through the head at one particular instant of time. In practice, of course, these imaginary bar magnets have no separate existence, and the tape is continuously magnetized in varying degrees throughout its length. When a record of this kind has been made, the question arises of how it is to be played back so that the sound may be reproduced. This is done by passing the tape across the gap in a play-back head. This head is fundamentally similar to the recording head, and for the purposes of this explanation, it can be the same one. This time, the coils of the head are connected to the grid of an audio amplifier. The core of the head is, of course, unmagnetized, and when the minute magnets on the tape are moved past the gap, they induce magnetism in the core material—just the opposite effect to the one used in recording—and since this magnetism is always varying, in accordance with the previously impressed sound, it is alternating in strength and direction, and thus induces an alternating voltage in the coils of the head. This voltage is amplified and applied to the loud-speaker in the usual way, thus reproducing the sound that was recorded.

SOME DIFFICULTY THAT ARISES

The basic principle that has been described in the previous paragraphs is the same one that has always been used in all the early attempts at magnetic recording. It obviously applies whether the material on which the record is made is steel tape, steel wire, or composite tape such as is used today. How is it, then, that the early attempts were only partially successful? The reason is to be found in the fundamental facts of magnetization itself. If we are to make satisfactory recordings by this means, there must be a straight-line relationship between the magnetizing force and magnetism that is retained by the material of the record. That is, equal increases or decreases in current through the coils of the recording head must produce equal increases or decreases in the magnetism that remains on the tape

after it has passed over the gap. If this is not so, then the magnetism of the tape after recording will not represent a faithful reproduction of the original exciting currents, and when the record is played back, the result will be distorted. This is a fundamental requirement of all recording and reproducing systems. In a disc record, the movement of the recording stylus must be directly proportional to the voltage applied to the windings of the recording head; in sound-on-film recording, the amount of light let through to the photocell of the film must be directly proportional to the voltage fed to the light valve when the recording was made. When an amplifier valve is used, the change in plate current must be directly proportional to the voltage impressed on the grid. In all these cases, we have the need for a linear relationship between input and output. Just what form the output takes does not matter, whether it is the current in a valve, or the amount of magnetism left on a tape, or the light allowed through a film by the variations in density of the image on it.

It is an unfortunate fact, therefore, that when we magnetize any magnetic material at all, the degree of residual magnetism is *not* in direct proportion to the strength of the exciting magnetic field. On the face of things, then, it would seem impossible to make magnetic recordings that are without distortion. Let us look at some graphs which illustrate just what we are up against.

In Fig 2 is shown the B-H curve of a typical magnetic material. The quantity B represents the magnetic flux occurring in the material, while H represents the magnetizing force. The magnetic flux density can be roughly defined as the strength of the magnetic field in the material itself, arising as a result of a magnetizing force H. *Ferro-magnetic* materials, or, as we know them better, simply *magnetic* materials, have the property of greatly increasing the number of magnetic lines of force within themselves when they are placed in a magnetic field. Some materials produce more lines of force than others, when placed in the same strength of field, and these are said to have a high magnetic *permeability*. Other materials produce very few extra lines of force, and are said to have low permeability. Others again give no increase at all in the number of lines of force, and these have a permeability of unity, and are commonly called *non-magnetic*. Now the curve of Fig. 2 shows what happens in a magnetic material when it is subjected to magnetic fields of various strengths. Let us imagine that initially there is no magnetizing force (or field) and that the material is unmagnetized. H therefore equals 0, and B must equal 0 also. The part of the curve O-A-B shows what happens when the magnetizing force is increase from zero. The flux density in the material increases too, in a manner according to the curve O-A-B. Note that the increase is slow at first, becomes greater, and then reaches a stage where the relationship between B and H is almost linear. Then, after A, the increase slows down again, as is shown by the curve bending over, until at B we find that however much we increase H, no more increase in B occurs. The material is then said to be *saturated*. Now we might fairly reasonably expect that if we start to reduce the magnetizing force, the flux density will decrease too, and will follow the curve from B back to A, and thence to 0 until we have no magnetizing force, and no flux once again. Unfortunately this does not happen. We find that when the field is decreased, the flux density does not follow the original curve back at all, but arrives at different values altogether, according to the part of the curve B-C-D. At C, it will be noticed, we have reduced H, the magnetizing force, to zero, but are left with a strong flux density represented in value by OC. This value of flux represents the magnetism remaining in the material after the magnetizing force has been removed, and it is partly a measure, for a given material, of its value as a permanent magnet. Now, if we reverse the direction of the magnetizing force, and increase its strength once more, the first effect on the magnetic material will clearly be to neutralize the remaining magnetism, and while this is going on, the flux density follows the part of the curve C-D. At D, there is no flux density at all, so that the material is now unmagnetized once more, but in order to arrive at this stage, we have had to apply a reversed magnetizing force equal to OD. This force is the force required to demagnetize the material after it has initially been magnetized to saturation, and is also an indication of the worth of the material as a permanent magnet. It is called the *coercive force,* and is even more important than the flux density OC when it comes to considering permanent magnetization. A material which is good for making permanent magnets has a high value of *remanence* (the name given to the value of flux OC) and *also* a high value of coercive force OD. Clearly, a high remanence means that the strength of the permanent magnet will be high, but this is little use unless the coercive force is high too, because the latter is a measure of the difficulty with which the sample can be demagnetized. A material with a low remanence, but a high coercive force will not make a very strong magnet, but will be very difficult to demagnetize, and so will hold its magnetism well. On the other hand, a material with a low coercive force will lose its magnetism when subjected to even very weak fields, and however high its remanence, it will not be "permanent."

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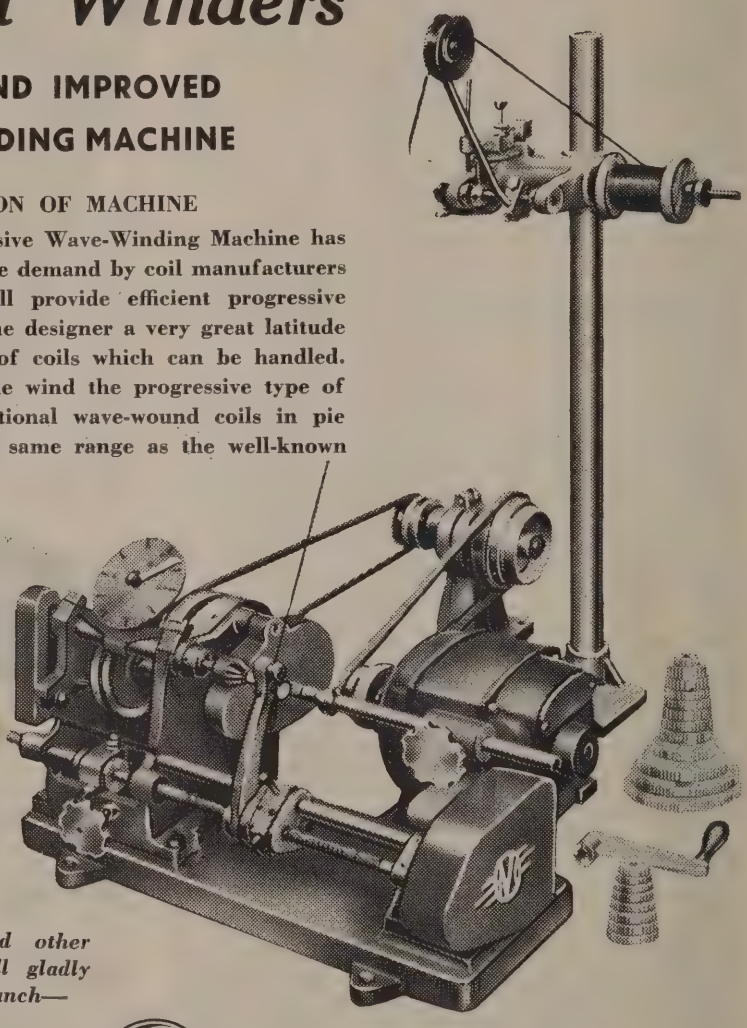
DESCRIPTION OF MACHINE

The "DOUGLAS" Progressive Wave-Winding Machine has been developed to meet the demand by coil manufacturers for a machine which will provide efficient progressive wave-wound coils giving the designer a very great latitude in the spacing and sizes of coils which can be handled. Not only does the machine wind the progressive type of coil, but also the conventional wave-wound coils in pie form with practically the same range as the well-known "DOUGLAS" Wave Winder



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Having reached the point D, we can still keep on increasing the magnetizing force in the reverse direction, and the flux will then become reversed itself. This simply means that the part of the sample that was originally a North pole becomes a South, and vice-versa. If we continue the process, we reach saturation in the reverse direction, as the curve gets to E. If now we start to decrease the field again, the curve E-F-G is followed. At F we again have no magnetizing force, but a flux OF, equal in value to OC, but opposite in direction. As we now reverse the field once more,, we trace out FG, where the material is again unmagnetized, and we have a magnetizing force OG equal to OD. Now as the force is increased in the original direction a second time, the path GB is followed. Thereafter, any

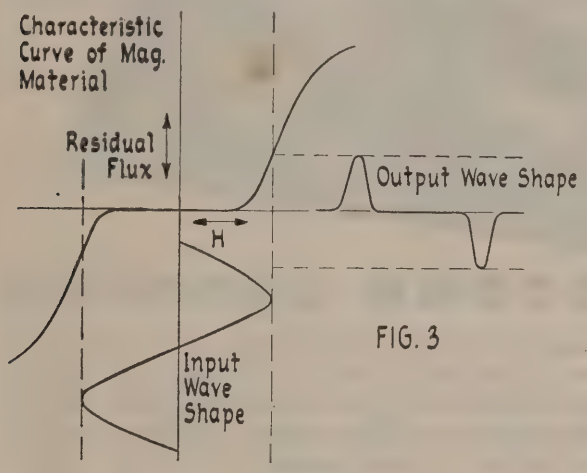


FIG. 3

changes in the magnetizing force result in the material tracing out the closed loop BCDEFBG. The thing to note here is that unless the material is de-magnetized. and then removed from the field, the first portion of the curve O-A-B is never re-traced.

We have spent some time in describing the magnetizing cycle of a typical magnetic material because this is the basis upon which magnetic recording rests, and also the cause of the difficulty in making good, distortionless records. Here is the point. If we take the material through its magnetization curve by means of a single cycle of alternating current, acting as the magnetizing force H, then the flux density in the material will behave according to the closed loop, and when the end of the cycle comes, the material is left with a flux density of either OC or OF according to the direction from which the force cycle approached zero. Now the recording consists of permanent magnetization of the tape in varying degrees, according to the sound currents, which are made to become the magnetizing force H by passing them through the recording head. The loop we have illustrated is the one we get when we take the material to saturation through having a very strong magnetizing force. Obviously, in order to see what happens at lower values of alternating magnetizing force, we need other curves as well, one of which is illustrated as the dotted curve on Fig. 2. In this case, the maximum magnetizing force represented by the peak current during the cycle is not great enough to take the material to saturation, and on starting from the demagnetized condition, the flux density reaches some point on the initial portion of the curve when the field starts to decrease after the peak current has passed. This time, the residual flux is only OX. Now it is possible to draw an infinitely large number of loops, each one for a given value of maximum magnetizing force, and corresponding therefore to a given A.C. amplitude at the recording head. For each one the loop shows a particular value of residual flux, and it is the manner in which the residual flux varies that determines whether the recording will be distortionless or not. The fact that the magnetic material has to go through the loop during every cycle does not in itself mean that the record will be distorted. If it so happened that the residual flux density was directly proportional to the peak value of the A.C. magnetizing force, then there would be no distortion at all. Now if we take all the points along the B axis in Fig. 2 and plot them against the peak magnetizing force needed to produce them as residual flux in the material, this gives us a

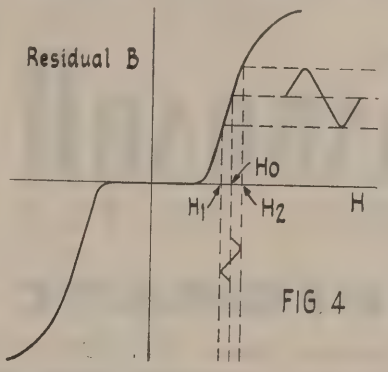


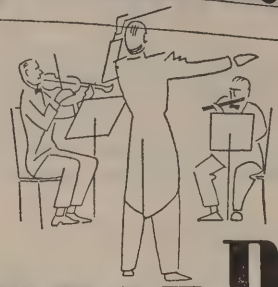
FIG. 4

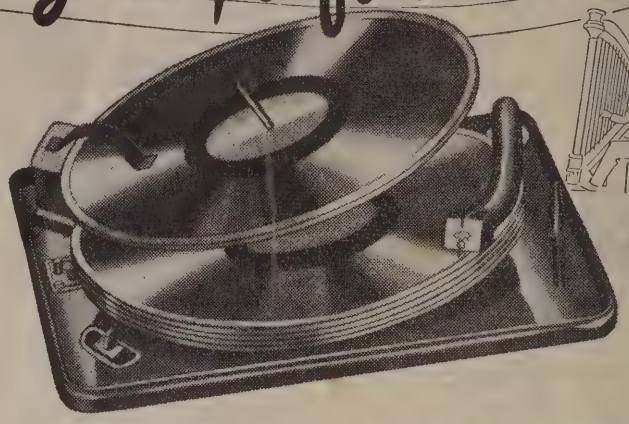
curve of residual flux against magnetizing field. If this is straight, then the system is distortionless. If not, then distortion will occur unless we do something about it. Fig 3 is the sort of curve that is obtained in practice when the above type of plotting is done. It is obvious from this that if the field follows a sine-wave shape, the resulting residual magnetization, and thus the output wave-shape when the record is played back, will be anything but sinusoidal. The actual wave-shape that would result from the charactersitic shown is also shown on Fig. 3.

WHAT CAN BE DONE ABOUT THIS DISTORTION?

The difficulty which we have taken so much space to describe was soon recognized by the early workers in the field of magnetic recording, and a partial answer was found to the trouble. It will be seen that apart from the highly curved piece in the middle, at low magnetizing forces, the curve is reasonably straight. If we can work the material only on this straight portion of its characteristic, then we will have a reasonably undistorted output. One way of doing this is shown in Fig. 4. Here a D.C. magnetizing force, or bias field is used. In the absence of any audio input to the recording head, there is a steady magnetizing force H_0 applied to the material. This can be done very easily by means of a permanent magnet held near the tape, or by having a separate coil on the head and passing D.C. through it. Now, the signal, or A.C. field, is applied, and this is sufficient only to swing the total force from H_1 to H_2. Over this part of the curve, it is straight enough to give reasonably low distortion, and recordings made with this system were the ones used, as mentioned earlier, by the B.B.C. and others. However, there were grave disadvantages in the D.C. bias scheme which prevented it from atttaining widespread use. The main difficulty was that of signal-to-noise ratio. On account of the D.C.

Outstanding in Performance





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MODEL R.C. 70A

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The Garrard Model R.C. 70A Record Changer will automatically play any number of records up to a maximum of ten 10 in. or ten 12 in. not mixed. The Model R.C. 70A is supplied complete with all fixing screws and patented suspension springs ready for fitting into cabinet. Cabinet space required for fitting is 15½ in. long by 13½ in. wide with 5½ in. clearance above, and 2½ in. clearance below top of motor board.

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- Automatically switches off and stops when last record has played.
- Fitted with the new Garrard Plug-in Pick-up Head. (Provisional Patent 4391/49.)
- Any record can be rejected whilst playing by moving knob to "reject" position.
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- Time of operation from finish of one record to commencement of next is four seconds.
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- Pick-up arm lifts to change needles.
- Specially designed, patented spring suspension eliminates mechanical resonance between pick-up and loudspeaker.

The Garrard Model R.C. 70A Record Changer is supplied in the following types:—

R.C. 70A/A.C.—A.C. only. Dual voltage range, 100/130 and 200/250 volts 50 cycles. A motor pulley for 40 or 60 cycles can be supplied if required.

R.C. 70A/6V.—D.C. only; 6 volts. Current consumption 2 amps.

R.C. 70A/12V.—D.C. only; 12 volts. Current consumption 1 amp.

R.C. 70A/D.C.—D.C. only. Dual voltage range 100/130 and 200/250 volts.

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bias, the steel tape which was used was always magnetized, even in the absence of an audio signal, and this led to a very annoying type of noise. This was due to the fact that the D.C. magnetization could not be held absolutely constant, so that undesired variations, due mainly to the non-homogeneous nature of the tape, were always present in the output during playback. As well as random noise, which gave a hiss similar to receiver noise, there was a continuous "whine," which was quite audible, and which spoilt the system for anything but the reproduction of speech. Listeners to the B.B.C. short-wave stations before the war will no doubt remember this noise, which made it quite possible to pick, even at this distance, when a talk was

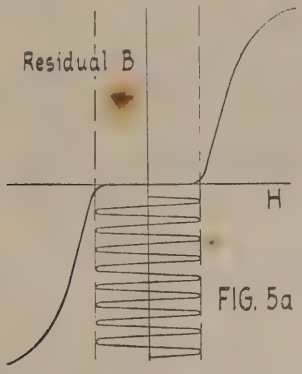

FIG. 5a

"live" and when it was recorded on the steel tape.

As was mentioned earlier, the most important of the modern developments in magnetic recording was the invention of a new method of overcoming the inherent magnetic distortion, and at the same time of removing the disadvantages of the D.C. bias system.

This development consisted in the use of what is now known as *supersonic bias*. This is strictly speaking, a misnomer, since the excitation at supersonic frequency is not really a bias at all. The term is a carry-over from the D.C. bias system, where the D.C. field could reasonably be described as a bias. In this system, the recording head is supplied with a strong field at a very high frequency—usually between five and ten times the highest audio frequency it is desired to record—and the audio signal is mixed with this high-frequency input. In actual recorders, the bias frequency is between 30 and 75 kc/sec. Now, in the absence of an audio signal, the net result of the supersonic field is nil, and the tape remains unmagnetized. This is due to the fact that the frequency is so high in relation to the width of the gap in the recording head, and this point will be explained later. However, when the audio frequency is superimposed on the supersonic field, the result is that A.F. is recorded, and with substantially no distortion. The mechanism of this type of bias is rather more complex than that of the D.C. bias scheme, but what has gone before will enable it to be explained. In Fig. 5 (a) we have the characteristic curve of the tape material, together with the supersonic head current, which is made just strong enough for the peaks to take the magnetic material up to the lower "knees" of the curve. It will be noticed that these knees are quite sharp, and that above them, the curve is quite straight .In Fig. 5 (b) we have the same material, with the supersonic field applied, together with one cycle of the audio frequency that is to be recorded. It will be noted that the supersonic frequency is not modulated by the A.F., but that the two are simply added together. In practice, this is done by feeding the two waves to the head at once, sometimes through separate windings, and sometimes through the same winding. Now, looking at the right-hand half of Fig. 5 (b), we see that the negative half-cycles of the A.F. cause the magnetizing force to extend up into the straight-line portion of the curve, and the output wave-shape can be seen by projecting the waveform on to the curve, just as is done with valve curves. The positive half-cycle is almost completely cut off, owing to the sharp knee in the curve, so that the right-hand part of the characteristic is concerned solely with reproducing the negative half-cycles of the audio signal. If now we look at the left-hand side of the diagram, we see that here, it is the positive half-cycles that are reproduced by the lower portion of the curve, the nega-

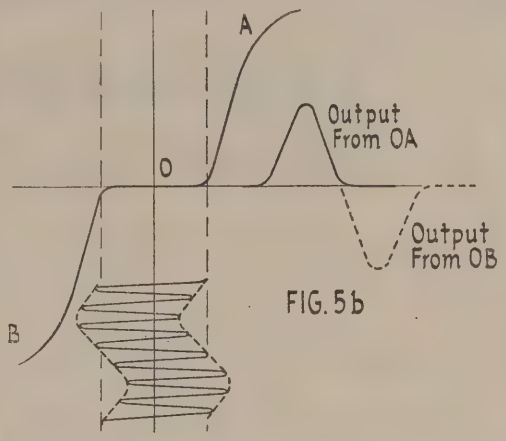

FIG. 5b

tive half-cycles being cut off in just the same way as the positive ones are by the other half of the curve. Now, since both these processes go on in the same piece of tape, the total result can be got by adding together the effects of the two parts of the characteristic. It can be seen that the output wavefom is almost a perfect reproduction of the original sine wave input. One cannot help but be struck by the resemblance of this method to the action of a Class B amplifier, one valve of which handles one half-cycle, and cuts off the other, and vice-versa for the other valve. In this case, the adding to the two signals is done in the output transformer. The purpose of the supersonic bias is to make the tape behave as if the flat centre portion of the characteristic were missing altogether. Thus, the effect is as if the flat portion were cut out, and the two straight-line bits joined up into a continuous straight curve.

ADVANTAGES OF THE SUPERSONIC BIAS SYSTEM

One advantage of the supersonic scheme over the D.C. bias scheme is very apparent. It is that a much greater portion of the magnetization curve can be used. This means that the magnetization actually put on the tape is much stronger than in the other arrangement. The total magnetization is not, but the *variation* in magnetization is several times that which can be used with D.C. bias. For this reason, a very great improvement in signal-to-noise ratio takes place immediately. This occurs both because the level of the wanted signal is increased, as mentioned, and also because the level of the unwanted signals, or noise, is very much decreased at the same time. There is no noise at all due to permanent magnetization of the tape, because this does not occur, the supersonic field leaving it unmagnetized unless there is an audio signal present as well. In high-

(Continued on Page 40.)

THE "RADIO AND ELECTRONICS" ABSTRACT SERVICE

AERIALS AND TRANSMISSION LINES:

The problem of a bend on a two-wire transmission line is analysed by the vector potential method. The equivalent circuit elements are obtained by comparing the variable line parameters near the bend with the conventional line parameters found on an infinite line.

—Proceedings of the I.R.E. (U.S.A.), June 1950, p. 679.

A method is described of calculating the mutual impedance of two crossed dipoles. It is found that, to a good degree of approximation, the mutual and input impedances may be expressed as very simple function of the angle of separation of the dipoles.

—*Wireless Engineer* (Eng.), July 1950, p. 209.

AUDIO EQUIPMENT AND DESIGN:

The acoustics of studios and auditoria—the contents of an informal lecture on the design of auditoria, reverberation, building materials, etc.

—*The Proceedings of the I.E.E., Part III*, July 1950, p. 257.

Wear on gramophone records caused by the reproducing points is a problem which has lagged far behind the development of sound reproduction. Microscopic examination of the stylus and the grooves of the records after wear throws light on the methods to overcome this problem.

—*Wireless World* (Eng.), July, 1950, p. 245.

A description is given of some of the new sound reproducing equipment at the B.S.R.A. Exhibition, by disc recording, magnetic recording, and the use of new accessories and components.

—*Wireless World* (Eng.), July 1950, p. 255.

The "Solovox" is a musical instrument produced by the Hammond Company of Chicago. It is a purely melodic instrument and requires some other musical instrument should accompany it, therefore the Solovox is designed to be attached to the front of a standard piano frame. An interesting feature is the methods of forming tone-colours.

—*Electronic Engineer* (Eng.), July 1950, p. 275.

A short interesting article describing simple modifications of a loudspeaker which extend the frequency range by three octaves, and suggests means of greatly improving reproduction.

—*Wireless World* (Eng.), July, 1950, p. 261.

Illustrations are given by an echo-free room at G.E.C. Research Laboratories, Wembley, the walls of which are built of cuniform "Fibreglass" layers to completely eliminate all echoes.

—*Electronic Engineering* (Eng.), July, 1950, p. 258.

CIRCUITS AND CIRCUIT ELEMENTS:

When negative feed-back is applied to a resistance-coupled amplifier having two or more stages, once a certain amount of feedback is exceeded the frequency characteristic develops peaks at the edges of the band. A careful analysis of the problem is given.

—*Wireless Engineer* (Eng.), July 1950, p. 201.

The paper contains a brief outline of the advantages and possibilities of cathode-coupled amplifiers. A rigorous theoretical analysis is established and some experimental results given.

—*Wireless Engineer* (Eng.), July 1950, p. 212.

The Miller time-base using a single valve is now well known; here is a description of a number of methods for varying the sweep of the Miller time-base at selected points during the sweep period, thus producing either an expansion or compression of some part of the trace.

—*Electronic Engineering* (Eng.), July 1950, p. 284.

An approximate analysis of the cathode-coupled multivibrator is given with an expression for the period of the output pulse in terms of the circuit elements.

—*Proceedings of the I.R.E.* (U.S.A.), June 1950, p. 655.

ELECTRONIC DEVICES:

Magnetic cores of fairly rectangular hysteresis loop material may be used as trigger devices, magnetic fluxes being used instead of electrical currents to indicate the two stable positions of the trigger. The paper shows how the magnetic flux level may be detected without a mechanical motion.

—*Proceedings of the I.R.E.* (U.S.A.), June 1950, p. 626.

MATERIALS AND SUBSIDIARY TECHNIQUES:

The paper describes the construction of electrical capacitors, shows the importance of excluding air and moisture from the dielectric and suggests how the sealing mechanisms may be assessed.

-*Proceedings of The I.E.E.* (Eng.), Part III, July 1950, p. 231.

A study of noise in variable resistors and potentiometers—rotation noise—frequency distribution, and the mechanical considerations to prevent noise.

—*Electronic Engineering* (Eng.), July 1950, p. 269.

MEASUREMENTS AND TEST GEAR:

The device described uses the selective property of a simple tuned circuit to isolate a particular component of frequency existing in a complex wave. The apparatus required for such a device is normally available in most laboratories or can readily be made.

—*Wireless Engineer* (Eng.), July, 1950, p. 197.

The paper deals with those methods of measuring mechanical quantities in which the initial mechanical-electrical transduction changes a resistance, capacitance or inductance or generates an e.m.f. A pick-up unit is chosen to meet the conditions of the test.

-*Proceedings of the I.E.E.* (Eng.), Part I, July 1950, p. 136.

An electronic chronometer is used to measure the time taken for a capacitor/resistance combination to discharge between given potential limits. Alternatively, the discharge time is compared with two fixed intervals to determine whether a component is within a given range of values.

—*Electronic Engineering* (Eng.), July 1950, p. 280.

The era of Geiger counters. A review of commercially-built instruments for the detection of radio-active materials with simple circuit diagrams.

Radio and Television News (U.S.A.), July 1950, p. 34.

Here is a design of a battery operated vacuum-tube voltmeter which is desirable when there is a possibility that power line hum may be transmitted by an a.c. operated instrument. The device is compact and easy to build.

—*Radio and Television News* (U.S.A.), July 1950, p. 43.

A Philips ionization gauge is described which is capable of measuring vacuum down to 10-7 mm of mercury.

Proceedings of the I.R.E. (U.S.A.), June, 1950, p. 651.

MICROWAVE TECHNIQUES:

The paper relates to the impedance of R.F. cables for microwaves and explains why the length of the cable has nothing to do with the impedance. A simple explanation is given for those who might have experienced difficulty in understanding the problem.

—*Wireless World* (Eng.), July 1950, p. 251.

Microwave lenses; the fourth article of the series deals with certain defects of lenses—spherical aberration, chromatic aberration, coma, and surface reflexions.

—*Electronic Engineering* (Eng.), July 1950, p. 264.

PROPAGATION:

Ground-wave propagation over an inhomogeneous smooth earth is discussed in relation to conditions which may occur in crossing a land-sea boundary where recovery of field strength may occur. The optimum conditions for obtaining the recovery are discussed.

—*Proceedings of the I.R.E.* (Eng.), Part III, July 1950, p. 209.

A source of the error in radio navigation or distance measuring systems involving the measurement of phase is discussed. Experimental evidence is given showing the effect of certain reradiating structures on the accuracy of such phase measurements.

—*Proceedings of the I.R.E.* (U.S.A.), June 1950, p. 612.

A description is given of a microwave propagation test conducted over a period of a year with simultaneous transmission on wavelengths of 16.2, 7.2, 4.7, and 3.1 cm. over a 42-mile overland path and the results indicate what may be expected in relation to wavelength and to time of day, winter or summer.

—*Proceedings of the I.R.E.* (U.S.A.), June 1950, p. 619.

TELEVISION:

An outline of the history of television is followed by a detailed description of the design and development of some English television pick-up tubes.

—*Proceedings of the I.R.E.* (U.S.A.), June 1950, p. 596.

Choice of television standards; the purpose of the article is to justify the decision made in Great Britain to restart the 405 line service, and to show that the standard is sound both from an engineering and an economic viewpoint.

—*Wireless World* (Eng), July 1950, p. 249.

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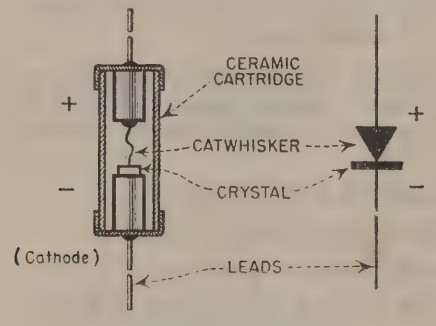
AMATEUR APPLICATIONS OF CRYSTAL DIODES

By the Engineering Department, Aerovox Corporation

The extensive development in electronics during World War II saw the return to active service of many circuits and devices which had previously been considered obsolete. Such things as the superregenerative detector, the magnetron oscillator, and the rotary spark gap were "resurrected," subjected to further development, and ultimately found important applications in military radio and radar equipment.

Not the least important among these "rediscovered" devices is the crystal detector. For, although the silicon, galena, or iron pyrites crystal,' with its ever-present "catwhisker," was a household item during the early days of broadcast radio, it was ultimately replaced by the vacuum tube. Then, when transit time and noise limitations ruled out the vacuum tube as a detector or mixer for microwave radar, the crystal detector was again resorted to.

As a result of this war-time rejuvenation, the clumsy crystal detector of old has emerged as the remarkably dependable, efficient, and compact unit known as the "semiconductor diode." These units are finding extensive usage in many types of circuitry. The amateur radio operator and experimenter has been especially quick to adapt the versatile, economical crystal to an ever-widening variety of uses. Some of these were touched upon in the October, 1946 issue of the *Research Worker*. This issue discusses some of the more recent uses for crystal diodes in amateur practice, and presents information on recommended types for specific applications.



CRYSTAL RECTIFIER AND STANDARD SYMBOL

FIG. 1

CONSTRUCTIONAL FEATURES

The present popularity of the crystal diode is due to the fact that its modernized construction makes it a practical circuit element which is capable of outperforming the vacuum tube in many instances. The elimination of the vexing process of searching for a "hot-spot" with a movable catwhisker by the use of a fixed rectifying contact makes it possible to package the crystal in a very compact capsule. This unit is also quite rugged and moisture-proof, since the capsule containing the diode elements is impregnated with a wax filler.

The general construction of a point-contact rectifier is illustrated in Fig. 1. The essential elements are the small "wafer" of a specially processed semiconductive material, a fine tungsten-wire catwhisker which is sharply pointed at the end in contract with the semiconductor, and an insulating body or capsule which holds these two parts in rigid contact and provides external electrical connections to them. There are several constructional variations which meet these specifications, each intended for a specific type of application. Some crystal diodes for R.F. application are designed for insertion into a "socket" consisting of spring contact fingers, while others intended primarily for low-frequency and video work, are equijjed with pig-tail lends and have the general appearance of small resistors or tubular capacitors. More reecntly, units which are hermetically sealed in glass envelopes have become available.

ELECTRICAL ADVANTAGES

In addition to the mechanical advantages of small size and ruggedness enumerated above, the point-contact rectifier has several important electrical attributes which make it preferable to vacuum tube rectifiers for for uses. Of course, one obvious advantage is the elimination of filament power consumption. This adds to the overall efficiency and makes it easy to use the crystal rectifier where the circuit must have low capacity to ground.

At extremely high radio frequencies, the two electrical characteristics which are most responsible for the usefulness of the crystal diode are the low inter-electrode capacitance and the short transit time. Since the sharpened point of the tungsten wire makes contact with the semiconductor over a very small area, the capacitance of modern crystal rectifiers may be less than one micromicrofarad. Transit time is negligible in most crystals because the rectifying "barrier layer" through which electrons must flow between the semiconductor and the metal contact may be only one *millionth* of a centimetre in thickness—much closer than it is possible to space the electrodes of a vacuum tube. For these reasons, the crystal has been used to detect R.F. energy well into the millimetre wave region.

CRYSTAL TYPES

Crystal diodes may be divided into two major categories; the high sensitivity types for high frequency detector and mixer applications, and the high-back-voltage variety which serve as general purpose rectifiers and second detectors. The high sensitivity kind are usually silicon crystals, while the high-back-voltage types are a germanium semiconductor.

Table 1 lists some of the various types which are, or have been commercially available, and gives the recommended use and upper frequency limit. As a general rule, crystal rectifiers can be used with good rectification efficiency and performance at any frequency below this limit.

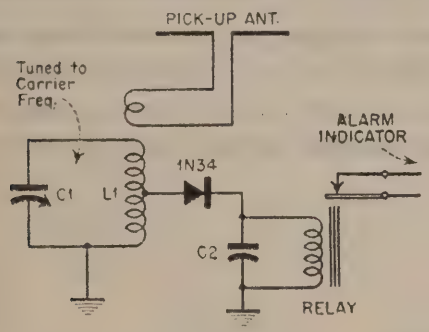
To date, the high-back-voltage family of crystal diodes has enjoyed the greatest popularity in amateur radio applications. This is due to the fact that a greater variety of low frequenccy uses for crystals as vacuum tube substitutes have been found. The 1N34 germanium diode, in particular, is used in dozens of circuit applications where a vacuum-tube diode such as the 6H6 or the 6AL5 would otherwise be employed. The high-back-voltage types are usually limited to frequencies below 100 mc. because the rectification efficiency of germanium falls off above this frequency.

With the growing use of the microwave amateur bands, it is expected that the silicon diode will be used to a much greater extent in amateur gear. At frequencies above the 420 mc. band the crystal mixer has decided

TABLE I CRYSTAL TYPES

NO.	USE	UPPER FREQ. (Mc.)	REMARKS
1N21A	Mixer (S)	3000	
1N21B	" "	"	Improved 1N21A
1N21C	" "	"	Most Sensitive
1N22	Inst. Rect. (S)	"	
1N23	Mixer (S)	10,000	
1N23A	" "	"	Improved 1N23
1N23B	" "	"	Most Sensitive
1N25	" "	1000	High Burnout
1N26	" "	24,000	
1N27	Video (S)	3000	
1N28	Mixer (S)	"	High Burnout
1N29	Video (S)	"	
1N30	" "	10,000	
1N31	" "	"	
1N32	" "	3000	High Sensitivity
1N33	" "	"	High Burnout
1N34	High-Back-Volt (G)	100	Gen. Purpose
1N35	" "	"	Matched Pair 1N34's
1N36-1N70	" "	"	2nd. Detectors, D.C. Restorers, etc.

(S) Denotes silicon crystal (G) Denotes germanium crystal



CARRIER FAILURE ALARM
FIG. 2

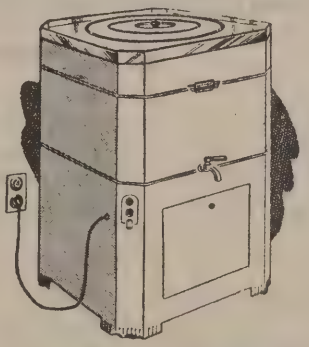
advantages over vacuum tubes from noise considerations. Crystal mixers have been produced which have noise figures approaching the theoretical optimum—the noise which would be produced in an equivalent resistor. Of course, since the crystal contributes no signal gain, the first I.F. stage succeeding it must also have a good noise figure. The low-noise cascode amplifier is ideal for this purpose.

APPLICATIONS OF GERMANIUM CRYSTALS

Most of the uses of germanium diodes in amateur work to date have been as meter rectifiers in R.F. detecting devices such as the TVI harmonic checker for locating spurious transmitter radiations which was described in the January, 1950 *Research Worker*. Detecting instruments of this kind, when tightly coupled and used with a microammeter, will indicate R.F. energy of only a few microwatts.

Other indicating devices which have basic circuits very similar to the harmonic checker are the crystal field-strength meter, the absorption wave-meter, and the modulation monitor. An interesting variation of this circuit is the carrier failure alarm shown in Fig. 2. It may be employed to ndicate the presence of R.F. power at the antenna of 'phone transmitters and so prevent "lost" transmissions due to the failure of the antenna change-over relay, transmission line, or other components. The alarm relay used must be of a sensitive type which will pull up at about one milliampere. The alarm indicator may be a signal light or a buzzer.

Another family of circuits which commonly use germanium diodes are the directional coupler type of standing-wave indicators and power monitors. Fig. 3 is the schematic of a typical resistance bridge standing-wave indicator which illustrates the principles of these very useful instruments. This simple circuit can be used to measure the standing-wave ratio existing on a transmission line and thus determine the impedance of the antenna or other transmitting device at its end. It consists of a resistance bridge which is balanced when the cable terminating resistance (Rx) is equal to R_1. Under this condition, no current flows through the germanium crystal and the meter reading will be zero. If, however, the load resistance does not equal R_1, the bridge is unbalanced and a current which is proportional to the degree of impedance mismatch flows through the crystal and is indicated on the meter. The value of R_1 must be equal to the surge impedance of the transmission line with which the bridge is to be used. Calibration may be



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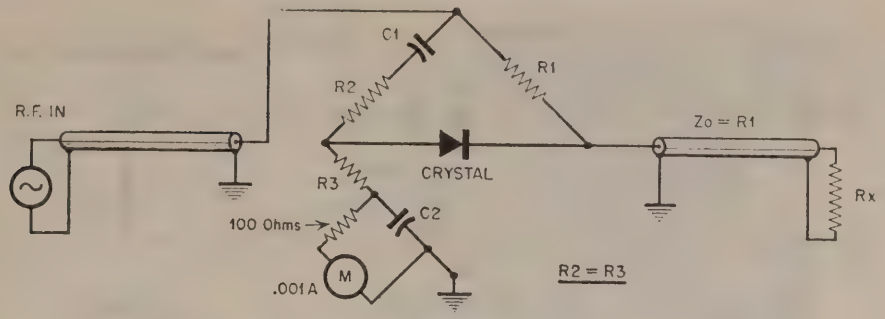
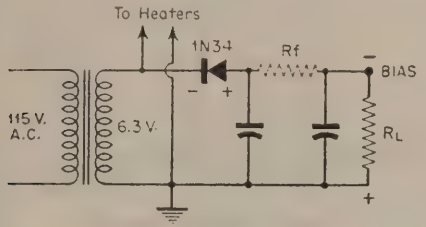


CRYSTAL STANDING-WAVE INDICATOR
FIG. 3

accomplished by connecting various non-inductive resistors of known value greater than R_1 across the output transmission line and noting the meter deflection. The voltage standing-wave ratio is then equal to Rx/R_1. A graph of VSWR versus meter reading may be plotted, or a special scale on the meter may be marked directly in VSWR. Before the readings are taken, the meter deflection is adjusted to full scale by open-circuiting the terminals to Rx and varying the R.F. input. This



BIAS SUPPLY
FIG. 4

variety of standing-wave indicator must be used at low input levels—preferably only a few watts. Other varieties, using other bridge configurations, are capable of handling greater powers.

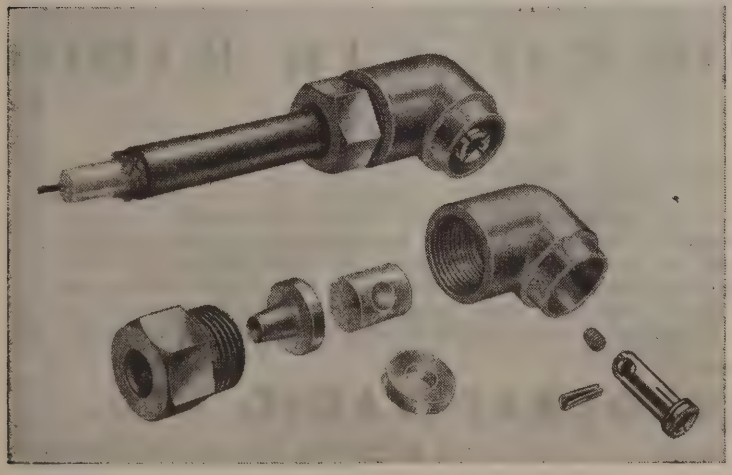
The germanium diode may also be used to provide a cheap and convenient source of low bias voltage. Fig. 4 shows a bias supply in which the A.C. heater voltage in the receiver or transmitter is rectified by the crystal diode and filtered by an R.C. filter. The output voltage may be adjusted by varying the filter resistance. Other rectifier circuits, such as full-wave and bridge connections may be used.

Still another type of application for the germanium diode family makes use of the negative resistance portion of the blocking voltage curve. This unique characteristic, which occurs when a negative voltage on the catwhisker is allowed to exceed the peak "blocking" voltage, has enabled the 1N34 and other high-back-voltage types to function as sine-wave oscillators and voltage regulators. Fig. 5 depicts basic circuits for these uses.

USES OF SILICON CRYSTALS

For frequencies above 100 mc/sec. a silicon crystal should be used in R.F. rectifying devices such as the harmonic checker, field-strength meter, carrier failure alarm, and the standing-wave indicator discussed above. The 1N22 is an instrument rectifier which is well suited to such applications.

The silicon crystal diode is also employed in other high frequency circuits where high sensitivity is required. The circuit of a typical H.F. superheterodyne crystal mixer is shown in Fig. 6. The bypass condenser (C_1) must have a low value of reactance at the carrier frequency but a high value at the I.F. frequency. Tuning is done by varying the capacitance between the inner and the outer conductors of the coaxial circuit.



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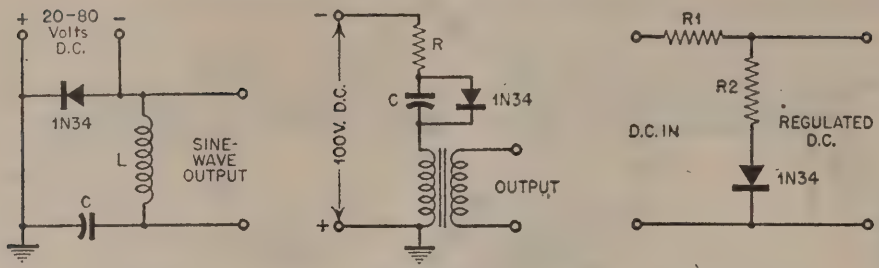


SINE-WAVE OSCILLATOR — RELAXATION OSCILLATOR — VOLTAGE REGULATOR

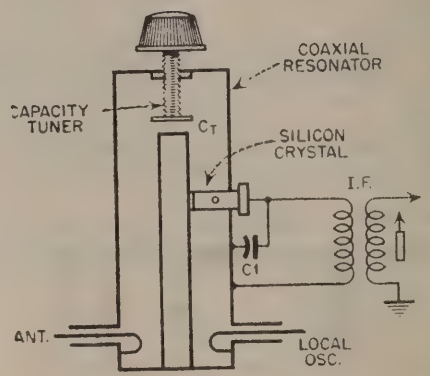
FIG.5

CARE OF CRYSTAL RECTIFIERS

In using crystal rectifiers of any type it is necessary to observe certain precautions to prevent damage to the unit. At no time should the rectified current be allowed to exceed the rated maximum value for that type. Otherwise, "burn-out" will occur and the unit will become useless. Although some types will withstand instantaneous surges of current of many times the rated average value, it is good practice to prevent such conditions which possible.

Crystal elements must also be protected from high temperatures. When soldering a unit with pigtail leads into a circuit, excessive heating may be prevented by grasping the part of the lead between the crystal and the connection being soldered with a pair of long-nose pliers.

A suitable test to determine the general condition of a crystal rectifier may be made with a high resistance ohmmeter, care being taken to avoid subjecting the crystal to excessive currents. The D.C. resistance of the unit is measured both ways by reversing the meter leads and noting the resistance in each direction. The "figure-of-merit" is the ratio of these "forward" and "back" resistances. A good unit should have a "front-to-back" ratio of at least 10:1 for silicon crystals and much higher (100:1) for germanium.



U.H.F. CRYSTAL MIXER

FIG.6

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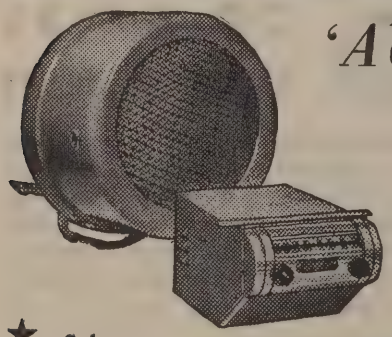

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OUR GOSSIP COLUMN

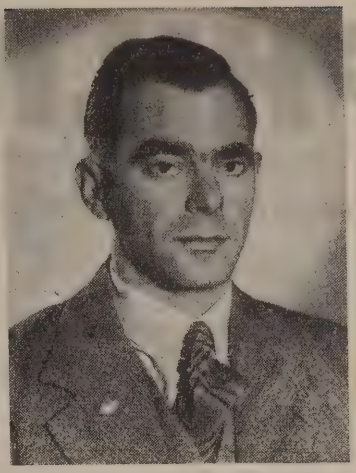
Inductance Specialists Ltd., now in its sixth year of operation, has moved into larger premises at 157 Thorndon Quay, Wellington. The new premises have been specially renovated and laid out so as to provide maximum efficiency for the production of radio coils and coil assemblies. New systems which have been instituted for checking and matching leave nothing to chance, and the whole lay-out of the premises provides ample room for quicker production and a more orderly system from start to finish. This progressive step, says Managing Director Ted Palmer, will speed up deliveries and provide for long term planning.

Ted Palmer needs little introduction to the radio industry and he is to be congratulated in this wise move of providing ample accommodation and modern methods and allowing for expansion of his organization. His connection with the trade goes back over the past twenty years and his enthusiasm for radio coils of a high standard is matched only by his ardent devotion and untiring efforts to maintain efficiency in this specialized service to the trade.

* * *

The announcement has been made of the appointment of Mr. Waldo Hunter of Auckland as Mullard representative, on behalf of the C. & A. Odlin Co. Ltd., for the Auckland Province.

Mr. Hunter has been associated with the radio and electrical trade for many years, and with the advantage of a practical technical knowledge, is well fitted to assist dealers with the many problems that are bound to arise through the growing use of electronic devices.



Mr. Ted Palmer

* * *

Recent visitors to Wellington include Brian Terry, Allan Rayner, and Jim Eckford.

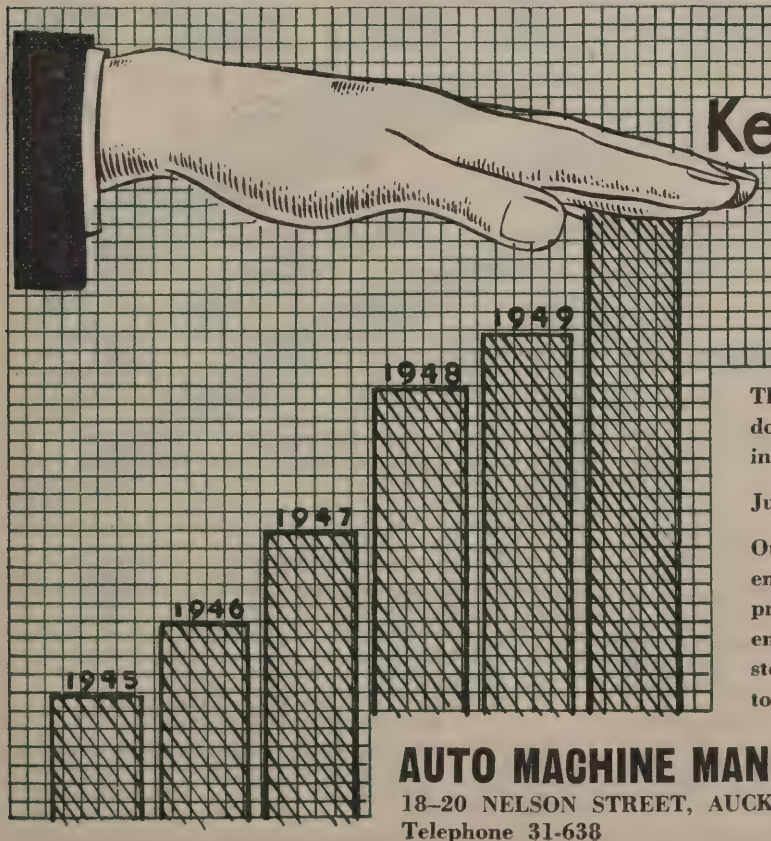
* * *

Wallace Clarke, Managing Director of H. W. Clarke (N.Z.) Ltd., has left for a business trip to Australia.

* * *

Noel Curtis, who has been in business on his own account for a few years in England, is shortly due back in New Zealand where he will join Swan Electri Co. and be located at Auckland. Noel will be remembered as having been with Dominion Radio, Auckland, and during the war, on the staff of the Ministry of Supply in England.

(Continued on Page 26.)



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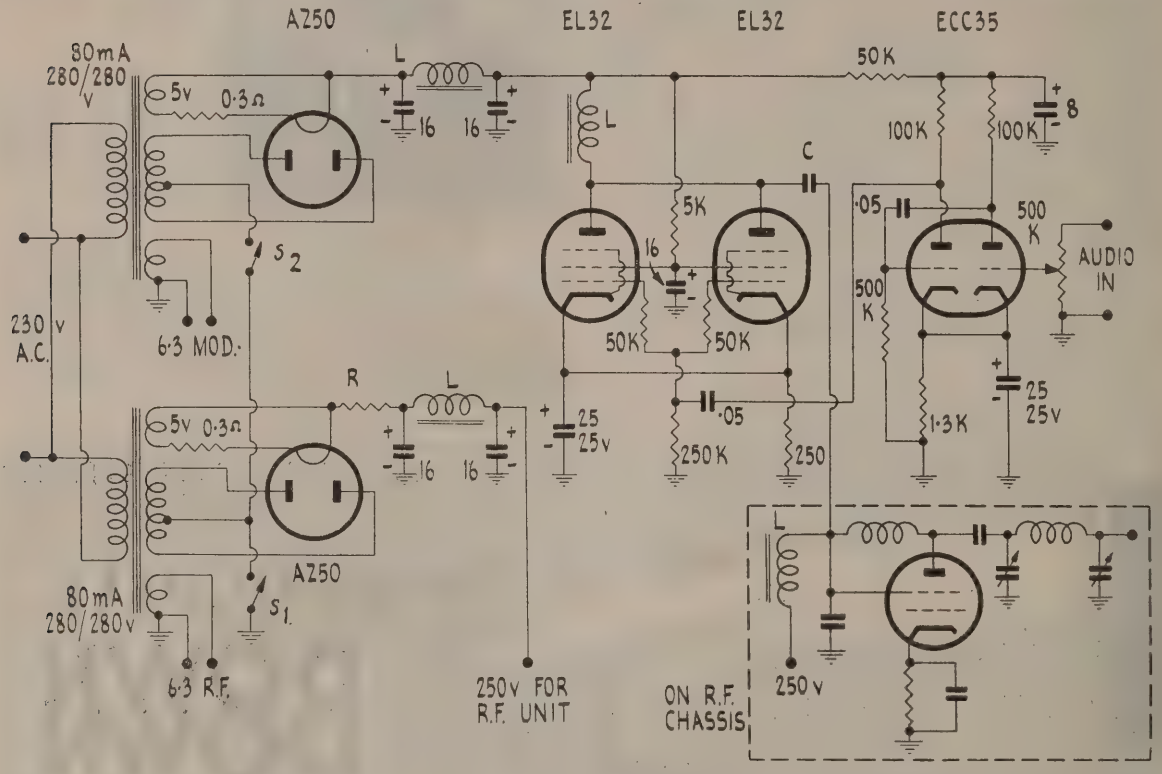
No. 36: A Low-powered Transmitter or Exciter for Six and Two Metres



PART III

In the last two instalments of this article, we described the construction and alignment of the R.F. section of the transmitter. This month, the job is completed with a description of a suitable power supply and modulator, which together with the R.F. unit, make a complete 'phone transmitter for both bands, in two small units. A glance at the circuit will show that there are two power supplies, one for the R.F. unit, and the other for the modulator and speech amplifier. These supplies are identical, in that the current drain for each unit is approximately the same, and because almost the same voltages are required on each also. Each supply uses full-wave rectification and a single stage of condenser-input filtering, and it should not be necessary to say much about these. The rectifiers are AZ50's, and these have 4-volt filaments. Thus, if standard transformers are to be used, it will be necessary to have resistors of 0.3 ohms in series with the 5v. supply windings. The transformers need secondary windings of only 280 volts a side, rated at 80 ma. Since these are stock transformers, they are reasonably priced, and in addition, two separate heater windings are available. If a single 150 ma. transformer were used, it may be difficult to get one to the exact voltage and current specifications, and it would probably have to be specially made, with two heater windings. The resistor R is inserted in the R.F. power supply in order to drop the output to 250 volts. This method is preferable to using a voltage divider, which would impose an extra current drain, and necessitate a larger transformer. The R.F. section's current does not vary very much, so that regulation is not an important factor. The value of R needs to be adjusted on the spot, to suit the transformer used. Its value will also be different from the original one if the input condenser is changed from the 16 μf. shown on the diagram to any other value. In the prototype, however, the value used was 500 ohms.

The smoothing chokes (and the two modulation chokes too) are 20H. 80 ma. units, as normally used in receiver power supplies.

CHOICE OF VALVES FOR THE MODULATOR STAGE

As was mentioned in an earlier instalment, the required modulator power output is only 6½ watts. This is very easy to supply, using a pair of almost any of the small receiving power pentodes in the Philips range, but the choice of valve is rather restricted because of other

considerations than the power output. First of all, it should be explained that a decision was made to use Heising modulation, mainly because suitable modulation transformers are not available. The smallest modulation transformer that can be purchased here is rated at thirty watts of audio power, and is rather large for handling only six watts! For this reason, push-pull modulators had to be discarded too, since any form of push-pull amplifier needs an output transformer when used as a modulator. The choice of valves then centred round the question of whether a single large valve, or two smaller ones in parallel, would be best for the job in hand.

Now with Heising modulation, there is no modulation transformer, so that if impedance matching is to be done between the modulator stage and the modulated stage (and this is essential) there is only one way to do it. Rather, there are two ways, but one of them cannot be used conveniently in the present instance.

The modulator valve or valves having been decided upon, a glance at the valve data sheets shows what load impedance must be used if maximum undistorted power output is to be realized. Now if the modulated R.F. amplifier does not produce a load for the modulator that is somewhere near this figure, then a mismatch will occur, and the required audio power output will not be obtained. This being the case, neither will 100 per cent. modulation! In some cases it is quite simple to alter the modulator's load resistance simply by making changes in the operating conditions of the modulated amplifier. For instance, if the plate voltage is increased, and the plate current decreased in order to bring the power input to the same as before, then all we have changed is the impedance into which the modulator valve "looks." Unfortunately, we cannot do this here, because we have the QV04/7 working at its maximum ratings of 250 volts on plate and screen, so that matching the modulator can only consist in using a valve whose required load resistance is equal to the actual input impedance presented by the QV04/7. As can be imagined, this requirement narrows rather considerably the choice of a modulator stage. Finally, it was decided that the nearest thing to meeting the requirements exactly was provided by a pair of EL32s in parallel, together with a slight "dodge" which would help to remove the slight mismatch that occurred.

This dodge consists in keeping the screen voltage at its allowable maximum of 250, and increasing the plate voltage to 300. This provides a little more power output, and at the same time raises the load impedance that was needed. The impedance of the modulated stage is 5000 ohms, and in the ordinary course of events, a single EL32 needs a plate load resistance of 8000 ohms. Thus, two in parallel would need a 4000-ohm load, which the Mod. Amp. cannot supply. However, by making the slight change in operating conditions mentioned, the matching is improved, and 100 per cent. modulation without distortion, is readily obtained.

The power transformer used gave exactly 300 volts output with the modulators working, and the 5k. screen

(Continued on Page 45.)

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VALVE NEWS

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DK32	X14	—
DL33	N16	—
DL35	N14	—
DAF91	ZD17	IFD9
DF91	W17	1F3
DK91	X17	1C1
DL92	N17	1P10
PM2A	LP2	P220
PM2B		PD220
PM2HL	{HL2, HL210} {HL2K, HL210}	HL2
PM12M	VS24, VS24K	S215VM
PM22A	KT2, PT2	Pen220
SP2	Z21, Z22	SP210, SP215
TDD2A	HD22, HD23, HD24	HL21DD
VP2	—	VP210, VP215
FC4	MX40, X42	—
PEN4	KT41, N41	AC2/PEN
PEN428	—	AC4/PEN
PEN4VA	MPT4, MKT4 KT42	AC/PEN
SP4	MSP4	AC/S2PEN
TDD4	MHD4, DH42	AC/HLDD
TH4B	—	AC/TH1
VP4	VMP4	AC/VP1
VP4A	VMP4G	—
VP4B	—	AC/VP2
2D4A	D41	V914
854V	MH4, MHL4	AC/HL
ACO44	PX4	PP3/250
PM24M	PT4	—
EB34	D63	—
EB91	D77	6D2
EC91	—	6L34
ECH35	X61M	—
EF91	Z77	6F12
EF92	W77	—
EL33	KT61	—
EL37	KT66	—
EL91	N77	—
EZ35	U70	—
PEN36C	—	PEN3520
TDD13C	—	HLDD1320
TH30C	—	TH2321
UAF42	WD142	—
UCH42	X142	—
UL41	N142	—
VP13C	—	VP1322
AZ31	U143	—
DW2	U10	—
DW4/350	U12	UU120/350
DW4/500	U12/14	—
IW4/350	MU12	UU3, UU4
IW4/500	MU12/14	UU5
UR1C	—	U4020
UY41	U142	—

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Our Gossip Column

(Continued from Page 23.)

RADIO TRADERS' BALL

The first annual ball of the Auckland Radio Traders' Association was an unqualified success for those who were there. Held on 24th August at the Metropole Cabaret, it developed into a first-class party which revived memories of the happy fraternal spirit which existed in the radio trade during the war years. Although earlier in the day, at the annual meeting of the association, members of the organizing committee had deplored the apparent lack of support for the ball on the part of the trade, the actual event was sufficient to make everybody determined to have another ball next year. The guests included Sir John and Lady Allum.

* * *

Sales in Palmerston North these days are keeping better than average, say many dealers, with whom it was the pleasure of *R. & E.* to meet on a recent visit to that city. Rees Furnishers were planning extensive alterations; Skelton Radios broadly advertise themselves by a well designed signwritten van; Swan Electric's new premises stand well to the fore with frontage of red and cream paint. Howard Rolands, that veteran of radio serviceman, now busy on V.H.F., looks well and says he has just completed 22 years of service operations (he looks good for another 22). The Stewart Brothers were on the list of calls and both look as if they have mastered the post-war problems to good advantage.

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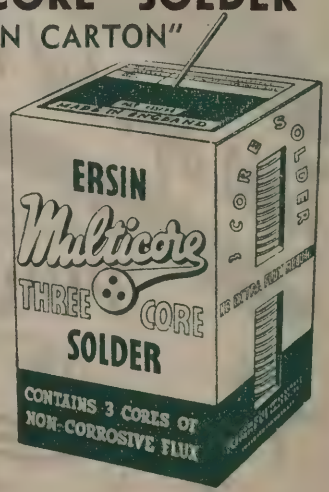

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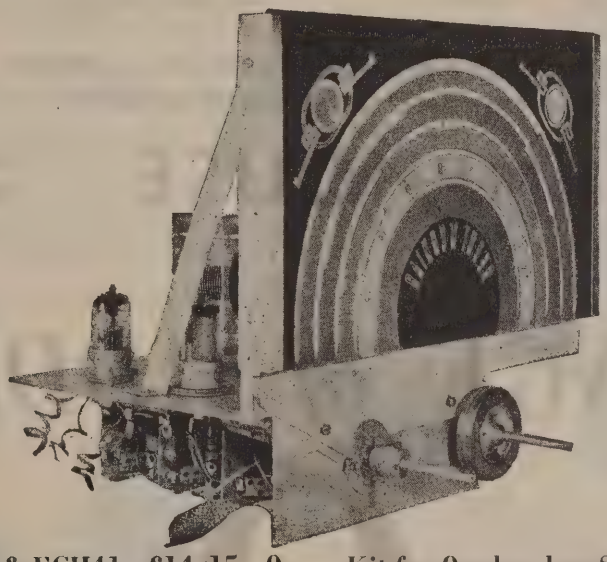

Tuner with EF41 & ECH41	£14	15	0	Kit for 9-valve, less Speaker	£28	10	0
Kit for 7-valve with Speaker	£27	10	0	7-valve Chassis, Cadmium		15	0
9-valve Chassis, Cadmium		17	6	Table Cabinet available	£5	0	0

Note: Dial Scales are available in two different colour schemes, one being brighter than the other.

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WONDERFUL VALUE

NATIONAL T.M.K.—100 mmfd. min. cap. 10 mmfd. P.V. 1500v. Air Gap .047, 17 plates, Isolantite Insulation. Cat. No. EX1611.....15/-

NATIONAL T.M.S. 250 mmfd. Min. Cap. 13.5, Air Gap, .026, P.V. 1000, 22 plates
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EGIL Cap. 150 mmfd. W.V. 3500, 12 plates
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RESISTORS WIRE WOUND
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I.R.C. 200 watts 1500 ohms, 10¾ in. x 1 in.
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TRADE WINDS

Auckland Provincial Radio Traders' Association

ANNUAL MEETING

The annual general meeting was held on the 24th August. Mr. H. J. Barr, who was in the chair, was re-elected for a further term as President. Other officers elected were:

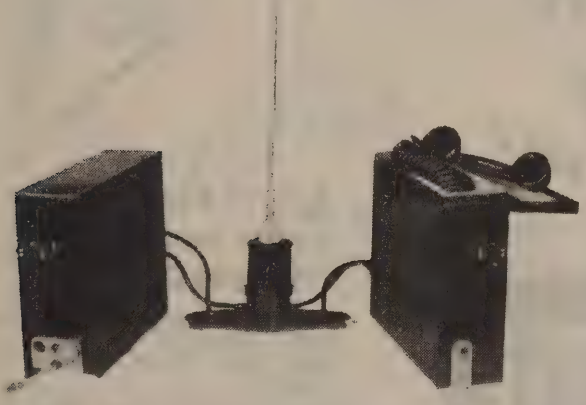
Immediate Past President: Mr. S. D. Mandeno.
Vice-Presidents: Mr. S. B. Christie and Mr. D. J. Reid.
Executive: Messrs. M. C. L. Rhodes, of Radio Repairs Ltd., W. J. Murphy of Radio (1936) Ltd., and C. R. Peoples.
Auditors: J. F. Buddle and Son.
Secretary: Mr. J. E. Beachen.

Representatives:

Chamber of Commerce: Mr. S. B. Christie.
Apprenticeship Committee: Mr. S. B. Christie.
Seddon Memorial Technical College Advisory Committee: Mr. R. J. Orbell.

Two-way Communication Equipment on Motor-cycles

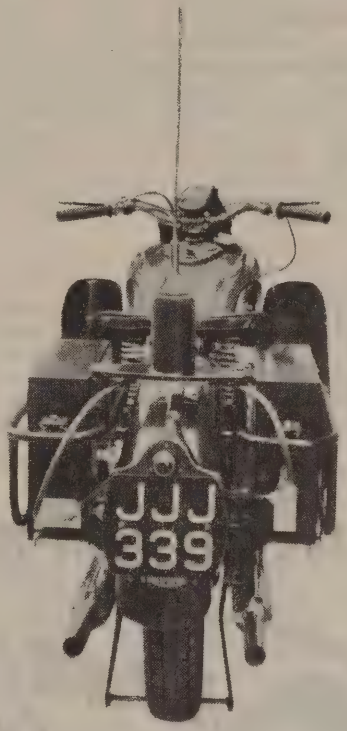
The Plessey Company Ltd., Ilford, Essex, announce that they have received a contract to supply to the London Metropolitan Police a quantity of Plessey transmitter-receivers, Type P.TR.7, for use on motor-cycles, and the associated control station installation. This equipment will play a valuable part in helping Scotland Yard to combat crime, and in aiding the police in their task of controlling traffic.



The equipment is described as follows: Frequency modulated, crystal controlled and operating on a spot frequency within the 68.0–100.0 mc/s. band, the 6-volt, 10-watt R.F. output transmitter-receiver, type P.TR.7, introduced by the Plessey Company Ltd. has been especially designed for use on motor-cycles.

A selective calling system is available whereby one, or all, of ninety units, each consisting of one or more vehicles, may be called from the control station. This system can be supplied either to "lock-out" all stations not being called, or to allow these stations to interrupt communication between the fixed and a mobile station should it be necessary. Notification of an incoming call is given by a bell or buzzer and a lamp.

Installation is neat and unobtrusive, the receiver with selective calling, transmitter and power unit being combined within two waterproof cases mounted on either side of the rear wheel. Every effort has been made both to distribute the weight evenly and to keep the centre of gravity low.



Power consumption on "standby" is claimed to be as low as 18 watts, service being about 20 miles, dependant on terrain and installation conditions, when operating in conjunction with a 20-watt control transmitter.

This 27-valve equipment is crystal controlled throughout, and therefore requires no adjustment in operation. Sensitivity is 1 microvolt carrier input for 10 dB quieting. Spurious responses are at least 60 dB down on wanted signal. Fully tropicalized in accordance with RCS 1000, all components are suitable for use within the temperature range —40°C. to + 71°C. with humidity as stated for K110.

It is stated that use of a low multiplication factor obtainable with the recently developed Plessey modulation technique virtually eliminates the radiation of spurious frequencies from the transmitter. Frequency deviation is ± 15 kc/s.

Publications Received

From Amalgamated Wireless Valve Co. Ltd., A completely revised 12-page Radiotron characteristic chart covering receiving valves. It includes an amended substitution chart specially useful when a replacement for an unprocurable valve is sought.

The Reciprocal Trade Federation of the United Kingdom: Booklet: "Television in Britain," by PYE Ltd., England.

N.Z. Lighting Service Bureau: Lighting Service Vol. 2, No. 9.

Ducon N.Z. Ltd.: Bulletin No. 101, "The Suppression of Radio Inductance Interference."

Philips Electrical Industries of N.Z. Ltd.: Electronic Measuring, Vol. 3, No. 2.

Industrial Electronics Ltd.: Descriptive literature, Brooks Crystal Frequency Control.

* * *

BRITISH RADIO INDUSTRY'S SPECIFICATIONS
FIVE MORE COMPONENTS COVERED

Five further specifications for components are published by the Radio Industry Council (England), making six so far in the series which will eventually cover all components in general use in the radio and electronic industries. The first, issued early this year, was RIC/122—Resistors Rotary Variable, Composition Track (with or without switches).

The new specifications are:

No. RIC/111—Resistors, Fixed, Wire-wound, Non-insulated.
No. RIC/112—Resistors, Fixed, Composition, Grade I.
No. RIC/113—Resistors, Fixed, Composition, Grade II.
No. RIC/131—Capacitors, Fixed, Paper Dielectric, Tubular Foil.
No. RIC/132—Capacitors, Fixed, Mica Dielectric, Stacked Foil.

At present the specifications are meant for use within the industry, but it is intended to submit them eventually to the British Standards Institution, by which time, it is hoped, it may be possible to co-ordinate the industrial and service needs in one comprehensive national standard.

Copies of the specifications are obtainable from the Radio Industry Council, 59 Russell Square, London, W.C.1, price 4s. each, post free, including the cost of schedules of types, values, and sizes, which are to be published later.

Note.—Copies of the above specifications are held in the library of *Radio and Electronics*, and are available for perusal at our office, 46 Mercer Street, Wellington.

* * *

BRITISH PLASTICS EXHIBITION AND CONVENTION, 1951

The British Plastics Exhibition and Convention is to be held in London from June 6 to 16, 1951, within the period of the Festival of Britain, in the National Hall, Olympia, and while primarily for the trade will be open also to the public. The exhibitors will be British and Commonwealth firms who produce, mould, or fabricate plastic materials or supply raw materials or equipment to the plastics industry.

The convention, which will run concurrently with the exhibition, is being organized by a committee on which are represented the British Plastics Federation, the Plastics Institute and the Plastics and Polymer Group of the Society of Chemical Industry.

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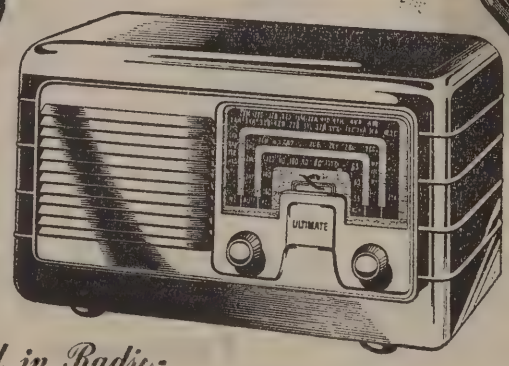
The POWER & PUNCH of a larger set!



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ATOMIC RADIATION DETECTOR

From Amalgamated Wireless A/sia Ltd. comes advance information on the C.K. Dosimeter and Charging Unit.

This dosimeter, manufactured by A. Kershaw and Sons in close collaboration with the Atomic Energy Research Establishment at Harwell, is a personal monitor for both Hard X and Gamma Radiation detection and measurement. The instrument is carried in the pocket and an internal calibrated graticule indicates the accumulated X or Gamma Ray exposure.

It has many applications, and forms an invaluable instrument for laboratory personnel working with radioactive materials, hospital, and industrial radiographers, scientists and industrial isotope users, etc.

The dosimeter also provides far greater protection than that given by the "film badge" type of detector where a time delay is involved before the dose received can be estimated.

Outwardly the dosimeter is similar to a small fountain pen, being 5 in. in length and ½ in. in diameter. It is fitted with a fountain pen type clip of sturdy design enabling the dosimeter to be carried in the pocket without fear of loss. Each instrument is engraved with a serial number so that where a large number are issued to personnel, a foolproof check can be kept on the dose received by each person.

Internally the dosimeter consists of a quartz fibre within a cylindrical ionization chamber, together with a calibrated graticule and a viewing microscope. A screwed cover at the end of the dosimeter protects the contact point of the fibre. When the ionization chamber is irradiated the quartz takes up a new position, the movement being directly proportional to the dose received.

To determine this dose, the dosimeter is held toward any light source and the graticule viewed via the eyepiece. A fine hair line—an image of fibre in the chamber—is seen on the graticule and a direct reading taken.

The graticule is calibrated from zero to 500 milli-roengtens in 25 m R steps.

The dose indicated is quantitive and the dosimeter is usable until the fibre indicates 500 milli-roengtens. When this condition is attained, the ionization chamber requires charging, and this is done with the Charging Unit.

This unit consists of a variable D.C. supply (obtained from batteries), a holder for the dosimeter and a light source enabling the graticule to be seen. Once charged, the dosimeter is immediately ready for further use. A screwed cap is fitted at the dosimeter protecting a spring plunger which makes contact with the quartz fibre when compressed. This cap should only be unscrewed when charging.

One charging unit will serve many dosimeters, and the time to charge one dosimeter is approximately 30 seconds.

* * *

"Radio Propagation and the Use of Antennas." Reprinted from *Signals* (July-Aug. 1949) *Radiotronics* No. 144 contains the above treatise by Col. Gauthier, Eucom Communications Chief. Of this article the Colonel says, "The form of presentation may be somewhat different from that of the usual treatise." To which A.W.A. add, "And How! And how delightfully so. Col. Gaither might have added to his title 'Techniques without Tears.' We hope you enjoy this as much as we did on first reading it."

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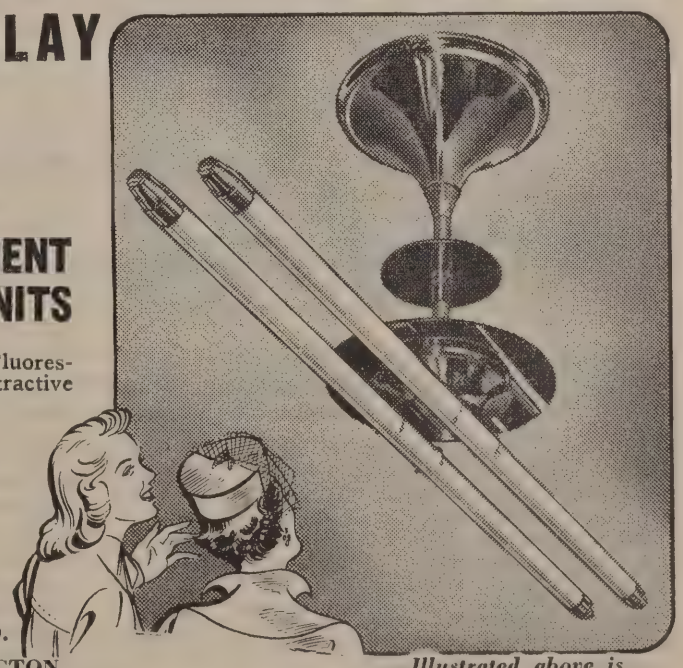

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Illustrated above is Model S.2

THE NEW ZEALAND ELECTRONICS INSTITUTE (Inc.) NEWSLETTER

Election of Officers:

At the Council meeting held on Saturday 26th August, 1950, the following officers were elected:—

President: Mr. W. L. Harrison, B.E., B.Sc., M.I.R.E., A.M.N.Z.I.E., A.M.I.E.E.
Vice-President: Mr. B. T. Withers, A.M.I.E.E.
Secretary: Mr. J. H. McIvor.
Treasurer: Mr. L. W. Hurrell, M.I.R.E.
Council: Combined Branches: Messrs. P. C. Collier, W. L. Harrison.
Auckland: Appointments yet to be advised.
Christchurch: Messrs. B. T. Withers, T. R. Pollard.
Dunedin: Messrs. W. L. Shiel, H. F. Symonds, B.Sc.
Wellington: Messrs. W. D. Foster, B.Sc., A.M.Brit. I.R.E., L. W. Hurrell.

Examination Papers:

In our last newsletter it was proposed to reproduce, for the benefit of students, a copy of a previous examination paper but it has been found that this would occupy considerable space to the detriment of general news. Under these circumstances students requiring a copy of a former examination paper may obtain some on application to the Dominion Secretary, P.O. Box 1368, Wellington.

Institute Prize Award:

In accordance with normal practice the Institute has this year awarded to Brian Martin Duff, of the Signal Radar Station, R.N.Z.A.F., Ohakea, an award for gaining the highest marks in the radio servicemen's examination conducted by the Electrical Wiremen's Registration Board of New Zealand, last March. The prize award conditions are detailed below and congratulations are extended to Mr. Duff on his success in winning the prize.

Conditions of award:

(*b*) The amount granted should not exceed in all the sum of £2 2s. (N.Z. currency) per prize.
(*c*) The Secretary obtain the name of the prize-winner from the Wiremen's Registration Board and indicate to him the nature of the prize.
(*d*) As circumstances permitted a similar form of prize should be considered for the Post and Telegraph Department technical examinations.
(*e*) The prize take the form of twelve months' subscription to a technical publication or similar reading material including text-books relating to electronics.

New Members:

At the August Council meeting the following new members were approved for admission in the status as detailed hereunder:

M.10 Dippy, Robert James, 12 Oku Street, Island Bay, Wellington, S.2. Member.

Am59 Andrews, Frederick Robert William, 2 Emmett Street, Wellington, S.1. Associate member.

AM.60 Farquharson, William Lowther, 33 Strathearn Ave., Wakari, Dunedin, NW2. Associate member.

AM.61 Nicholls, Lloyd Wilson, 93 Nevay Road, Miramar, Wellington E5. Associate member.

AM.62 Turner, Albert Leslie, c/o Telecommunication Section, Civil Aviation Branch, Air Dept., Bunny Street, Wellington. Associate member.

A.145 Rothschild, Peter Henry, 83 Grant Road, Wellington, N.1. Associate.

A.146 Suttie, George Fraser, Civil Aviation Branch, Air Dept., Wellington. Associate.

Branch Secretaries:

If members are desirous of keeping up to date with Branch activities they should maintain contact with their Branch secretaries as detailed below:—

Auckland (Acting Secretary): Mr. A. O. Valentine, 33 High Street, Auckland.
Christchurch: Mr. A. V. Butcher, 236 Riverlaw Terrace, St. Martins.
Dunedin: Mr. W. McInnes, P.O. Box 243, Dunedin.
Wellington: Mr. R. G. Currie, 6 Landcross Street, Kelburn.

Subscriptions and Certificates:

Subscriptions as detailed hereunder are now due and payable either to your Branch Treasurer or to the General Secretary, Box 1368, Wellington. When subscriptions are received members are automatically placed on the distribution list for *Radio and Electronics*, and a certificate according to membership grading is prepared and dispatched.

Member: £3 15s.
Associate Member: £2 15s.
Associate: £2 10s.
Student over 21: £2.
Student under 21: £1 10s.

Branch News:

Auckland: Two meetings were held during August with a view to electing officers for the year but the attendance at both these meetings was not very good.

Council would ask all Auckland members to rally round their officers and give more support in the future to local activities.

Christchurch: Members in Christchurch recently had the pleasure of hearing an address by their Chairman, Mr. B. T. Withers, A.M.I.E.E.

Mr. Withers, who is the Dominion Vice-President, spoke on "Sound and Audio Frequency Currents" with the definition of Simple Harmonic Motion and an explanation of its meaning by reference to a simple pendulum. From this, the speaker showed the development of a sine wave, so illustrating the similarity between the oscillations of a pendulum and the change in voltage occurring across a capacitance in an oscillatory circuit.

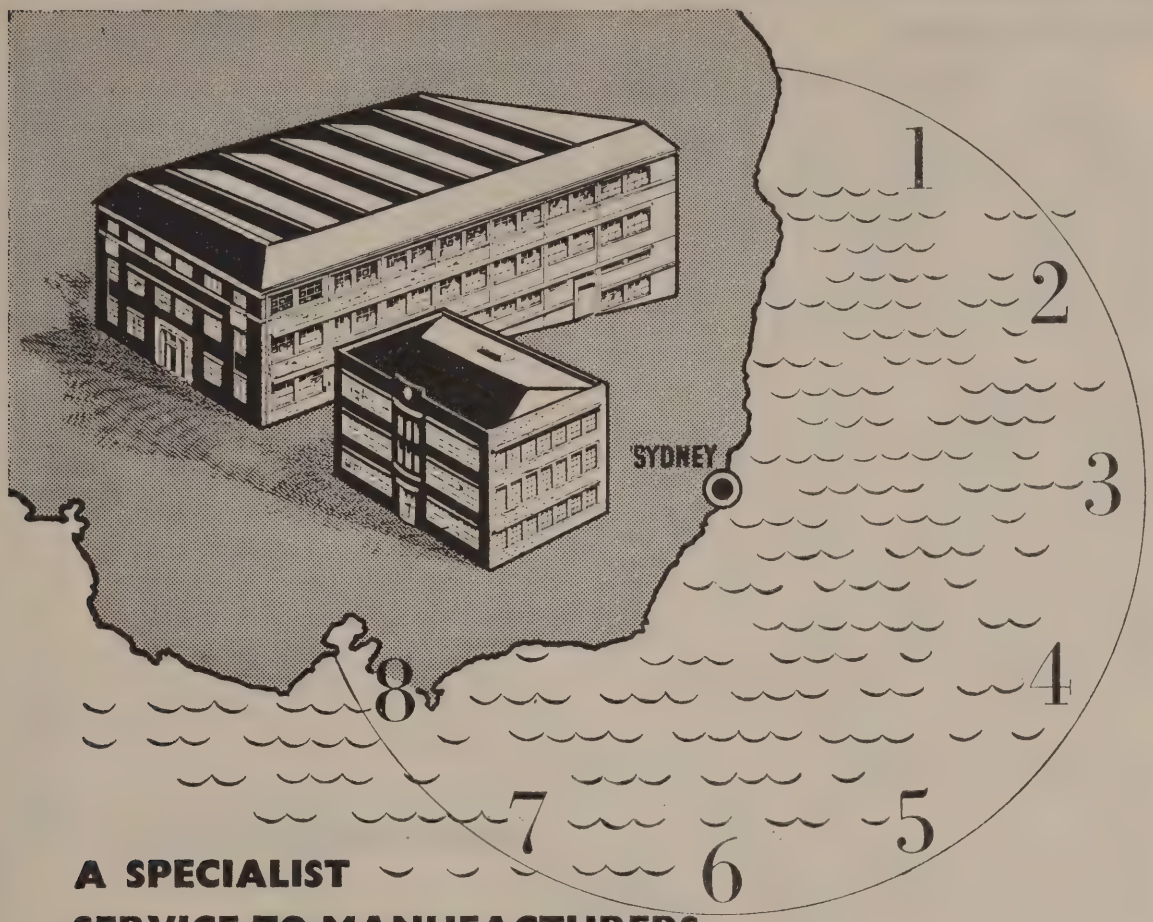
With the aid of rotating vectors, he then gave a graphical explanation of the development of a sine wave, together with associated harmonics.

Members were shown the actual waveforms on oscilloscopes. It was demonstrated that "second harmonic distortion" was distinguished by *asssymmetrical* distortion of the waveform, whereas "third harmonic distortion" was characterized by *symmetrical* distortion of the waveform.

Mr. Withers referred to the accepted fact that "phase distortion" as such, is not perceptible to the human ear, but pointed out that some perceptible affect must occur on "transients" where a square wave was approached.

The speaker concluded with an interesting demonstration of the composition of a square wave. A square wave was generated and passed through "low pass filters" such that the fundamental body only was passed. The frequency of the square wave was then decreased and the waveform studied as each harmonic was added. With the addition of the fifth harmonic the square was relatively square, increasing in squareness as each successive harmonic was added.

After a vote of thanks, proposed by Mr. Pollard, Mr. Withers invited members to investigate and experi-



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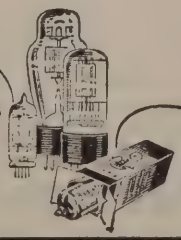

VALVES

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Auckland, Wellington, Christchurch, Dunedin, Hamilton, Wanganui, Hastings, Invercargill.

F.M. Reception Without Discriminators

One of the things that seems to prevent amateurs and experimenters generally from delving into F.M. transmission and reception is the difficulty associated with getting the conventional types of F.M. detector to work. Discriminators and ratio detectors require special I.F. transformers, and are difficult to align for proper operation without the use of specialized equipment such as F.M. oscillators and oscilloscopes. An idea which may enable many amateurs to start on F.M. reception and transmission is put forward by Joseph Marshall in the latest issue of our American contemporary *Radio-Electronics,* to reach us. The idea is to use a double-conversion superheterodyne receiver in which the second I.F. is, say, 200 kc/sec. There then follows, after this converter, a pair of resistance-capacity coupled stages of amplification for 200 kc/sec. These look just like audio amplifiers, except that no bias is used, in order that these valves may act as limiters, clipping the output voltage at a fixed level irrespective of the voltage input to the receiver. There then follows a detector circuit known as the pulse counter circuit. This is a simple arrangement consisting of a double-diode valve, shunt-fed by the plate of the last amplifier valve, by a small coupling condenser of 25 $\mu\mu$f. One diode is simply connected with its plate to the coupling condenser and its cathode earthed, while the other is connected with its cathode to the coupling condenser, and its plate earthed through an R.F. filter circuit and a 50k. load resistor.

This arrangement has been used for many years as the basis of a direct-reading audio frequency meter, simply by replacing the 50k. load resistor by a sensitive meter movement. If square-waves of fixed amplitude are applied to the input of such a device, the direct current through the diodes (either will do) is directly proportional to the frequency of the square-wave. Now the output of the receiver in this case is a train of square-waves because of the limiting action of the two 200 kc/sec. amplifier stages. And the frequency varies in accordance with the modulation on the original carrier. If the maximum deviation is, say, 75 kc/sec. above and below the carrier frequency, after conversion to 200 kc/sec., the same variation will take place, so that the variation is now from 275 to 125 kc/sec.—more than a two-to-one variation. Thus, the diode load current will vary in accordance with the varying frequency of the input, and the audio signal will appear at the output of the diode with the load resistor in series with it. The detector output is approximately 1 volt, so that not very much audio amplification is needed after the detector. The linearity of this kind of detector is very good indeed, and there are no critical adjustments whatever. Alignment of the whole set is just as easy as that of a normal A.M. set, since there are no special response curves to obtain so that distortionless detection shall take place.

It seems to us that this scheme might be just what amateurs have ben waiting for to enable them to indulge in F.M. transmission for the high-frequency bands. If smaller deviations are used, it will be possible to use lower I.F.s for the second conversion, thereby increasing the efficiency of the counter type of detector. If a lead is needed we might consider ourselves the design of a simple F.M. system using this as a basis of the design. F.M. is allowable on the 50–54 mc/sec. band, and, of course, the higher ones too, so that the "difficult" V.H.F. bands need not be used for any experimental work.

FOR THE SERVICEMAN

Basic Circuit:

A type 1P5GT remote-cut-off pentode is used as a tuned radio frequency amplifier, and is inductively coupled to the frequency changer. The frequency changing stage utilizes a type 1 A7GT heptode. A type 1P5GT remote-cut-off pentode as the intermediate frequency amplifier follows which is in turn coupled to a type 1H5GT diode high mu-triode combining the functions of detection, AVC rectification and voltage amplification. The triode section of the 1H5GT is capacitively coupled to a type 1Q5GT beam power amplifier delivering approximately 370 milliwatts to the type 6H Rola speaker. H.T. voltage is derived from a synchronous vibrator system and filtering is by means of a brute force network.

I.F. Alignment 460 Kc/s.:

A signal generator modulated 30 per cent. at 400 cp/s is coupled between the control grid of the 1H5GT and ground by means of a .1 μf. condenser. Intermediate frequency transformer cores should be adjusted in the following order, T4, T3, T1 and T2. 430 microvolts input should produce an output of 50 milliwattrs.

Calibration:

Adjust 1400 kc/s point by means of T7 and 600 kc/s point by means of T8.

Adjust 1000 kc/s point by means of I3. Repeat procedure until all point are correct.

Alignment:

A signal generator modulated 30 per cent. at 400 cp/s is coupled between antenna and ground leads by means of a standard dummy antenna. Adjust for maximum output at 1400 kc/s trimmers T5 and T6. Adjust for maximum output at 600 kc/s iron cores I1 and I2.

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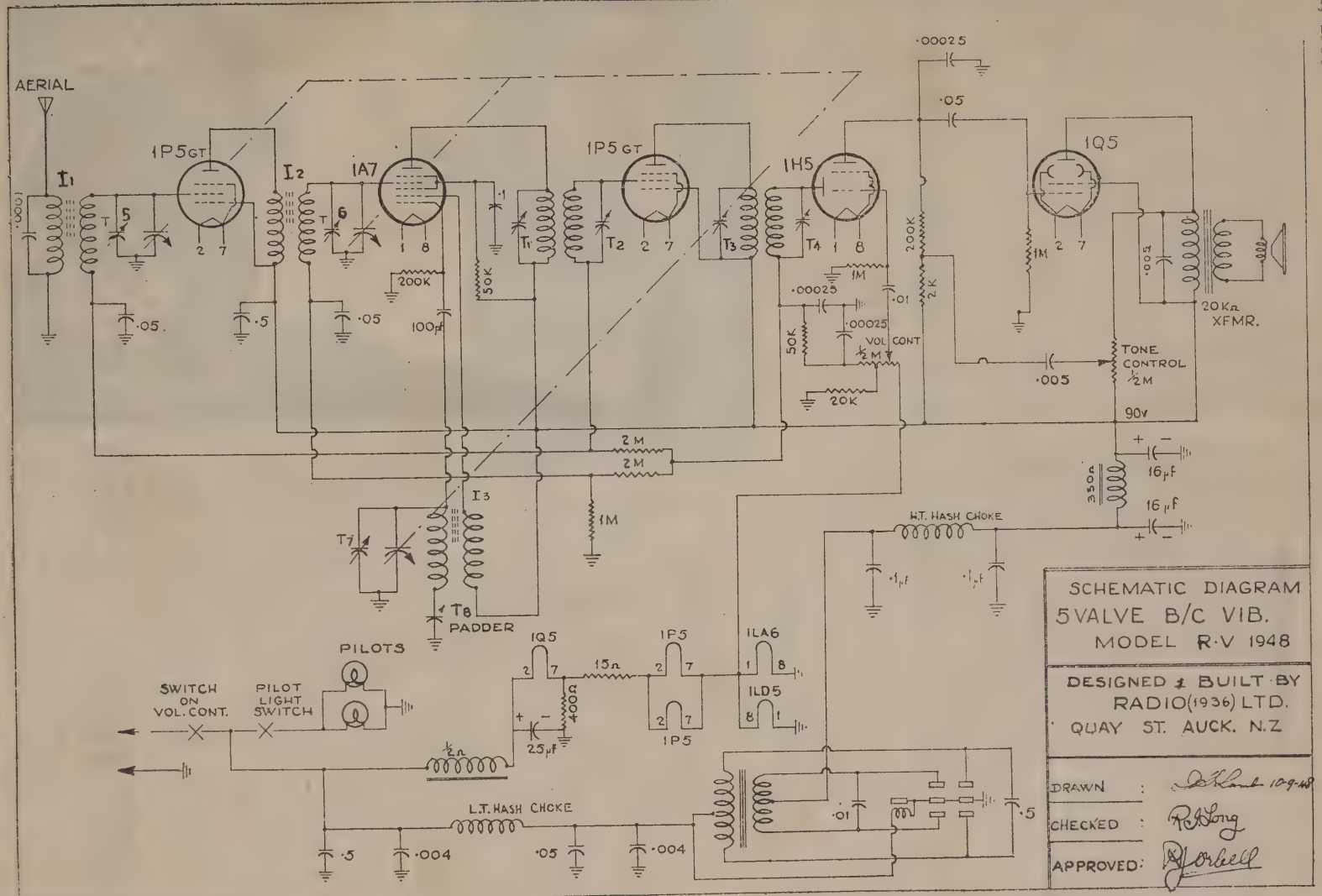
FOR THE SERVICEMAN—The Ultimate 5-Valve Broadcast Vibrator Model RV



"R. & E." Communications Receiver

(Continued from Page 6.)

anyone should have difficulty in visualizing the arrangement, we have printed Figs. 1 and 2. Fig. 1 shows the basic arrangement for coupling two tuned circuits together by this method, and it can be seen that the coupling between V_1 and V_2 on the main circuit diagram conforms to this. C_1 and C_2 on Fig. 1 correspond to C_{26} and C_{31} respectively, while the series combination of C_{23}, C_{24}, and C_{25} corresponds to Fig. 1. The only remaining point that may cause difficulty is that on Fig. 1 both coils are shown earthed at the "cold" end, while in the circuit, neither is directly earthed. This, however, does not affect the arrangement, because as far as L_2 is concerned, it is earthed for all practical purposes by the bypass condenser C_{22}, whose whole purpose is to have so little impedance at I.F. that it looks like a short-circuit to earth for all except D.C., which does not concern us when we are dealing with signal currents or voltages. Similarly, the "cold" end of L_3 is earthed for signal frequency by the bypass condenser C_{17}. Fig. 1 is therefore a sort of circuit shorthand for the arrangement coupling V_1 and V_2 together. In practice, L_2 is used to feed H.T. voltage to V_1, just as is done with a normal I.F. transformer primary. At this point, when we have partially described the coupling circuit from V_1 to V_2, it seems logical to complete the description of the coupling circuit and show how the variable selectivity comes about.

HOW THE VARIABLE 455 KC/SEC. SELECTIVITY WORKS

It was mentioned above that the variable selectivity switch has been shown in the "broad" position. Now, it is well known (and we have treated the subject in some detail ourselves in previous articles) that bottom-capacity-coupling scheme can be used to provide various degrees of selectivity. For instance, if in Fig. 1 we increase the capacity of C_3 without doing anything else, two things happen. First, the coupling between the two coils is *decreased,* resulting in greater selectivity, and secondly, the coils are both detuned. The latter effect takes place between C_3 is part of both tuned circuits, and changing it must therefore alter their tuned frequency. Now in attaining variable selectivity, we do not want to have to get out the screw-driver and retune the I.F. amplifier every time we work the selectivity switch. Thus, any switching arrangement used *must not* alter the tuning, but must only vary the coupling between the coils. Fig. 2 shows how this is done in the present set. This is the exact arrangement, except here again, the "cold" ends of the coils have been shown directly earthed. Again, the switch is in the "broad" position, so that the correspondence between the two circuits is exact. It will be noted that there are *two* condensers each labelled C_1 and C_2. This is to indicate at a glance that the condensers concerned are equal in value. Referring Fig. 2 back to Fig. 1, we see that with the switch as drawn, the 100 $\mu\mu$f. condensers correspond with C_1 and C_2, while the left-hand block in Fig. 2, consisting of C_1, C_2, and C_3 in series, corresponds to C_3 on Fig. 1.

If now we imagine the switch moved so as to bridge between the lower ends of the condensers C_1, we have a different set of values above and below the connecting link. For instance, C_1 and C_2 on Fig. 1 are now represented by 100 $\mu\mu$f. in series with C_1 (on Fig. 2) while C_3 on Fig. 1 is represented now by C_2 and C_3 in series on Fig. 2. Note that bringing the switch down one step has brought in the right-hand C_1 to the circuit, but that the right-hand C_2 is still not in use. Now what are the electrical effects of making this change? First of all, the capacity corresponding to C_3 on Fig. 1 has been increased. Secondly, the capacity corresponding to C_1 on Fig. 1 has been decreased, because C_1 is now represented in the circuit by 100 $\mu\mu$f. in series with the left-hand C_1. Thus, the coupling between the circuits has been decreased, and a little further consideration will show that the tuned frequency has not been altered. Both coils are tuned by capacities equal to 100 $\mu\mu$f. in series with C_1, C_2, and C_3. Now when the switch was in the top-most position, the coils were also tuned by capacities equal to 100 $\mu\mu$f. in series with C_1, C_2, and C_3, so that the tuning capacities have not been changed, and no de-tuning can therefore exist as long as the condensers C_1 are equal in value. If now the switch is moved to the lowest position, each coil is still tuned by the same value of capacity, but the coupling condenser is now C_3 on its own. The lowest position of the switch thus represents the least coupling between the circuits, and therefore maximum selectivity. If any readers are still not quite sure about the principles involved in this coupling system, they are recommended to read an article published in the March 1950 issue of *Radio and Electronics,* entitled "A Variable-Selectivity I.F. Amplifier System," where the principle is described in detail, and the present three-position scheme is suggested.

The coupling circuits between V_2 and V_3 is identical with that between V_1 and V_2, and so needs no separate description. The switches are, of course, ganged, and operated simultaneously. The three degrees of selectivity chosen have been arranged with an eye to the fact that this is a communications receiver. That is to say, the

broadest position gives a pass band similar in width to that of a conventional single-stage I.F. amplifier in a broadcast set. The medium position gives rather a smaller pass band, while the narrow position gives the narrowest pass band that the Q of the circuits will allow. In all three positions, however, the skirt selectivity will be about the same, because with any system of variable selectivity that does not use damping to broaden the response, the rate of attenuation at the skirt of the selectivity curve remains substantially constant.

THE CIRCUIT OF V_2 AND V_3

The second 455 I.F. amplifier stage has been made a 6AR7-GT. This is because the mutual conductance and consequent gain of this valve is quite high, and because it also has diodes that can be used as the A.V.C. rectifier. It is perhaps more usual to use one diode of a 6H6 as the detector, and the other as the A.V.C. rectifier, but this has some disadvantages, chief of which is that it is difficult to achieve a good lead lay-out in the A.V.C. circuit. This is highly undesirable, especially when there are two stages of I.F., because the lead from the A.V.C. rectifier to the plate of the last I.F. stage carries the highest I.F. voltage to be found in the set—higher even than is found at the detector diode. However, when the A.V.C. diode is in the same envelope as the last I.F. amplifier, there is no problem at all, because the A.V.C. feed condenser can be wired directly across the socket without difficulty, and there is virtually no lead at all. The risk of instability through radiation from the high-potential A.V.C. feed lead is thereby completely removed. Another advantage is that one diode of V_3 is

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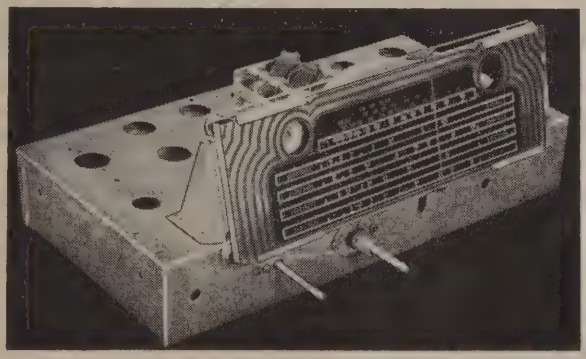

The unit consists of a chassis suitable for either 7- or 9-valve circuit with the tuning condenser, dial assembly, and coil unit already mounted.

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Five separate tuning ranges cover the broadcast band and the short-wave bands from 2.5 to 18 mc/s., divided into four semi-spread ranges, thus the unit gives complete coverage with spread tuning on both the amateur and overseas broadcast frequencies.

Features of the unit are: Band indicator mounted on the dial. Tropic proofed cerise wax impregnated coils. Selected silvered ceramic and silvered mica spreading condensers. Rotary type ceramic trimmers on the oscillator section. Iron-cored broadcast coils. Accurately matched space-wound short-wave coils. Solidly mounted coil assembly in three self-contained banks, comprising coils, trimmers, and wave-change switch. Ceramic insulated 3-gang Polar condenser.

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freed for use in other ways. Here, it has been used as a normal series noise-limiter diode, to supplement the action of the Lamb noise suppressor. In our opinion, the A.F. noise limiter is hardly necessary, but some builders will prefer to omit the Lamb circuit and rely on the diode noise limiter, and in this case the circuit is already there, and will require no modification apart from omitting the parts that are not wanted. There is one unusual thing about the detector circuit. It is that the cathode of the detector diode is not earthed. Instead the other end of the diode load resistor is earthed. This has no effect on the working of the detector circuit, which will be recognized as conventional. Another peculiarity about this part of the circuit is the rather odd-looking bias circuit of V_2. In the first place, it will be noticed that V_2 has no A.V.C. on it. This is quite common practice in sets with more than one I.F. stage, and actually improves the A.V.C. characteristic of the set, in spite of the fact that one fewer stage is controlled. That being so, a minimum bias of —2v. is required for V_2, and this must not be altered when the set is under manual control either. Thus, cathode bias is indicated for V_2. Now the normal method of producing a delay voltage for the A.V.C. system of a set in which the A.V.C. diode is part of another amplifier tube, is to return the A.V.C. diode load to earth, and allow the positive cathode voltage to become the A.V.C. delay voltage automatically. This is all very well, but gives no control over the value of the delay voltage, because cathode voltage is fixed by the requirements of the pentode section, which bear no relation at all to those of the A.V.C. delay voltage. Thus, in order to allow V_2 to have its —2v. grid bias, but also to provide a considerably higher A.V.C. delay voltage, a much larger cathode resistor is used than would be needed to produce only 2 volts of cathode bias. In practice we have about ten volts at the cathode. This is a suitable value for the A.V.C. delay, but is much too great for the pentode section, whose gain would be seriously reduced with such a bias. Therefore, the grid return of V_2 is taken not to earth, but to a tap on the cathode resistor, at a point 2 volts negative with respect to the cathode. Thus, both the pentode section and the A.V.C. diode have their requirements met separately. R_{25} and C_{47} are necessary as de-coupling for the grid return circuit, in order to avoid all possibility of negative feedback occurring, and causing loss of amplification. It might be thought that the bypassing of the cathode resistor might be sufficient for this purpose, but the filter R_{25} C_{47} has been included as an additional safeguard.

THE LAMB NOISE SUPPRESSOR

This part of the circuit comprises V_{10}, V_{11}, and V_1. It thus requires two extra valves, but the results amply justify their inclusion. In principle, this noise suppressor is very simple. V_{10} is an extra I.F. amplifier, whose grid is fed by resistance-capacity coupling from the plate of V_1. In the plate circuit of V_{10} is a special I.F. transformer which has a tuned primary, and an untuned centre-tapped secondary winding. The latter is closely coupled to the primary, and has a step-down ratio, so that the impedance level at the secondary is rather lower than at the plate of the amplifier. V_{11} is a full-wave rectifier, and since it is desired to take output from it in negative polarity, the cathodes are earthed as far as signal is concerned, and the output is taken from the centre-tap of the transformer secondary. There follows an R.F. filter, C_{19}, L_8, and C_{27}, whose purpose is to remove any remaining R.F. voltage from the rectifier's

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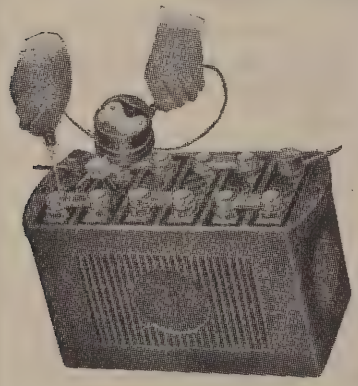

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output. The resulting audio frequency output is applied to G_8 of the heptode section of V_1.

How, then, does this arrangement reduce the effect of R.F. noise voltages picked up by the receiver? First of all, let us look at the detailed circuit of V_{10} and V_{11}. From H.T.+, there is a bleeder consisting of R_{40}, R_{41}, and R_{42}. Of these, R_{41} is a potentiometer, whose moving arm supplies a controllable positive potential. This is applied to the cathodes of both valves. As far as V_{10} is concerned, then, this control, which is brought out to the front panel, acts simply as a manual bias and gain control. But the rectifier cathode also is connected to the same point, so that a positive bias is fed to this cathode, and has the same effect as a negative bias applied to the plate. Thus, the setting of R_{41} determines how much voltage input is required to make V_{11} conduct, and it acts as a threshold control. For instance, if the cathode of V_{11} is set by R_{41} at 10 volts positive, any signal at the transformer secondary whose amplitude is less than 10 volts *peak* will not cause V_{11} to conduct, and there will be no output from the rectifier. Suppose, however, that a modulated carrier of peak amplitude just under 10 volts is present, and that from time to time high-amplitude noise pulses appear. These pulses may be due to ignition interference, or to any other cause, and it is likely that their amplitude is considerably greater than that of the modulated carrier. Let us suppose that it is 18 volts peak. Now at no stage will the rectifier V_{11} function on the signal, because the threshold control has been set at plus 10 volts, and the peaks of the positive modulation half-cycles just fail to reach this level. But when an interfering pulse comes along, its amplitude of 18 volts causes the diodes to conduct, and a pulse appears in the output of the rectifier equal in amplitude to the difference between the threshold voltage, and the peak amplitude of the pulse. In this case, the rectifier output of V_{11} would be a pulse of 8 volts peak amplitude. Now because of the way in which the rectifier is connected, this pulse will start from earth potential and will go negative, taking the third grid of V_1 with it. If the pulse has travelled from V_1 through V_{10} and V_{11} and back to V_1 without appreciable delay, then the third grid of this tube is driven negative for the duration of the pulse, and instead of a large pulse output appearing in the output of V_1, the latter has its output momentarily reduced to zero. In short, the action of the noise suppression circuit is to cause the noise pulses to cancel themselves out! In the case cited as an example, the output from the rectifier would have been sufficient to cut off the plate current of V_1 completely for the duration of the pulse.

Now the theory of the Lamb noise suppressor has been presented only very roughly in the preceding paragraphs, and there are one or two serious objections that can be made to the description given. First of all, however, it should be pointed out that the circuit used here, while almost identical in detail with the original one of Lamb, has one very important difference. In his circuit, the input to V_{11} was taken not from the output of V_1, but from in parallel with its input. This difference may appear slight, but in fact it is very important. If the description given above were strictly examined, it would be found that the system would not work, for we are cancelling a pulse taken from the *output* of V_1. Thus, there must be a pulse at the plate of V_1 for the suppressor to work, so that proper cancellation is impossible! However, readers need not let that put them off the circuit, which certainly does cause a substantial noise reduction in practice. In the original Lamb circuit,

(Continued on Page 48.)

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Tape Recording

(Continued from Page 15.)

fidelity tape recorders, the inherent noise is so low that a far wider dynamic range can be recorded than can be done with disc recording of any kind, so that at its best, tape recording is now probably the best medium known. At its best, it leaves disc and sound-on-film standing. At its worst, it can be very poor indeed, and it is the purpose of these articles to enable those who may undertake magnetic recording, to get the best out of the equipment they use or build.

ADJUSTMENT OF SUPERSONIC BIAS

The explanation given above shows very readily why it is that in any given recorder, the adjustment of the level of the supersonic bias is important, and why it is fairly critical. It can be seen that if the peaks of the supersonic field do not extend right up to the knees of the curve, there will be an appreciable portion of the distorted half-cycle reproduced, and cancellation of the distortion will not take place properly. If, on the other hand, too great a bias field is used, the strength of the audio field that can be used will be limited, and the signal-to-noise ratio will be adversely affected, since less audio signal can now be used before distortion sets in due to the upper curvature of the characteristic. If much too much bias is used, the effect will be to degrade the signal-to-noise ratio still further, because the curvature of the characteristic will result in distortion of the bias current, and this is equivalent to, and actually produces a D.C. magnetization component, which has the same noise-making attributes as the intentional D.C. bias system. In practice, the bias input to the head is most easily adjusted with the aid of an oscilloscope. This is connected so as to show the input/output curve, and with this on the screen, the bias is adjusted until the curve is as straight as possible, indicating least distortion.

OTHER FACTORS IN TAPE RECORDING

So far, we have been discussing the basic principles only, but there are a number of factors which have a decided bearing on the question, and which in their own way are just as important as the way in which the tape is magnetized. For example, there is the question of the speed of the tape; this influences directly the upper limit of frequency response of the system. The design of the recording and playback heads is another important matter which affects frequency response and distortion. The mechanical side of the job is no less important, since any deviation from constant speed in the tape driving mechanism will cause flutter and "wow" which, if bad enough, can make the recorder quite useless. Then there is the matter of how recordings can be wiped off so that the tape can be used over again. All these things must be taken care of in the design and operation of a tape recorder, and it is essential that the would-be user should have an understanding of all of them. Then again, there is the frequency response of the system to be properly organized, for if left to itself, the response from the tape is anything but flat over the useful audio range. This means that special compensating circuits have to be used, and also that any ordinary amplifier with a flat characteristic cannot be used, either for recording or playback. For the remainder of this article we will deal with these topics, and give a comprehensive view of the whole subject.

RECORDING HEADS AND TAPE SPEED

Fig 1 shows the construction of a typical tape recording head. At A is the core, which is built up of fine laminations of mu-metal. It has two gaps, at B and C. B is the recording gap, and C is another one opposite B, whose purpose will be described later. On each leg of the core is a winding, which may be of comparatively few turns, giving the head a low impedance, or which may have many turns of finer wire, giving the head a high impedance. Whether a high or low-impedance head is used is largely a matter of convenience, and since a transformer is always used to feed the head, the point is not one of fundamental importance, although there are reasons for preferring the low-impedance variety in certain circumstances. The gaps in the core are exceedingly small—only about two thousandths of an inch in width—and the tape is pulled across the recording gap, in close contact with the gap. Very often, the core is made circular so that the tape touches the core just at the gap and nowhere else, but plain rectangular heads like the one illustrated are quite practical, and with careful work are fairly easily made by hand.

One of the most important characteristics of the head is the width of the gap, and there is an optimum width. If the gap is too wide, several disadvantages occur. The first is that the field between the halves of the core, instead of being concentrated in the gap, tends to spread out at the edges of the gap. This is known as fringing, and occurs with any gap, however small. It is much worse, however, with wider gaps, and its particular disadvantage is that the fringing of the field tends to de-magnetize the tape after it has passed the gap proper. The result is that the magnetization of the tape is not as strong as it might be, and the recorded level is too low, resulting in a poor signal-to-noise ratio. Another effect of the gap being too wide is even more important. It is that the high-frequency response that can be put on the tape is severely limited when the gap is too wide. When it is said that the gap is too wide, this implies that *it is too wide in relation to the speed of the tape past it.*

In order to see why this is so, let us again consider for a moment the basic magnetization process. The tape is running past the gap at a certain speed. When we wish to record a certain audio frequency, the problem is to produce a variation in magnetization of the tape along its length. Now if the frequency is very high, then the length of tape that can be affected by the magnetizing field during one cycle of the frequency is very short, and just on general principle it can be appreciated that if the time of one cycle is so short that the tape has hardly moved at all from the beginning of the cycle to the end, then there will be no sensible variation of magnetism at all on the tape. If the tape is run at constant speed, then there will be a particular wavelength on the tape for each audio frequency. Now this wavelength has nothing to do with the width of the gap in the core, but only with the speed of the tape. For example, suppose the frequency is 100 c/sec., and the tape speed is 7½ in. per second. One cycle of this frequency lasts 1/100 sec., during which time the tape will have moved one hundredth of 7½ in., or 0.075 in. Thus, each cycle occupies 0.075 in. of the tape, and this is the wavelength of 100 c/sec. on the tape. With this knowledge, it is easy to work out the wavelength of any other frequency. For instance, 10,000 c/sec. would have a wavelength of 0.00075 in. or three-quarters of one-thousandth. Since the gap is of the order of one or two thousands of an inch, it is obvious that with this tape speed, the size of the gap must have some effect on the way in which 10,000 c/sec. is recorded. It has been found that the magnetiza-

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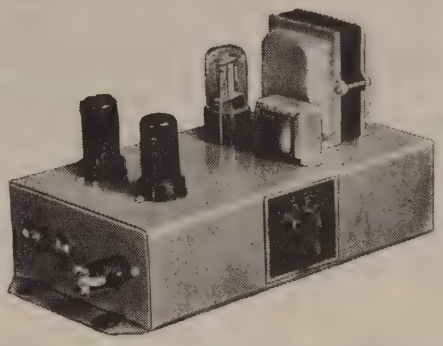

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tion due to any particular frequency is *zero when the wavelength on the tape is equal to the width of the gap.* It is also a *maximum* when the gap is equal to half a wavelength on the tape. Thereafter, at higher frequencies, every time the gap is an odd multiple of a half-wavelength, the response reaches a maximum, and every time it is an even multiple of the gap length, the response is zero. At low frequencies, the response is almost proportional to the frequency, until the first maximum is reached, as stated above. Thereafter, the shape of the response curve is that of a series of hills and valleys, the height of the hills decreasing gradually as the frequency is made higher and higher. This behaviour is illustrated in Fig. 6, where we have plotted the response curve, not in terms of frequency, but in terms of wavelength on the tape, for a speed of 7½ in./sec. The wavelength is expressed as a multiple of the gap length. For those who are interested in formulae, the best expression of the response curve is the formula, below, which has been found to work well in practice. it is:—

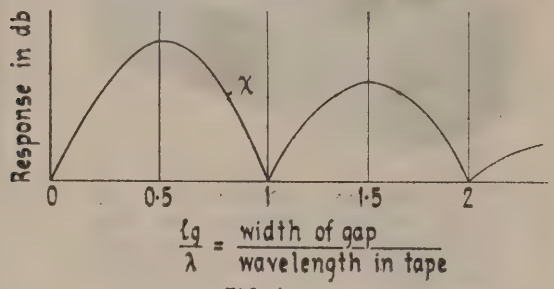

FIG. 6

$$E \text{ is proportional to } S_t \sin \frac{\pi l_g}{\lambda}$$

where S_t is the speed of the tape, $\pi = 3.14$, l_g is the length of the gap, and λ is the wavelength of the tape.

Those mathematically inclined will recognize the similarity to the formula for the vertical radiation pattern of a dipole above a conducting earth, and the formula obviously leads to a curve of the shape given in Fig. 6.

Now, no one wants a response curve which is full of hills and valleys, and which has frequencies at which there is no response at all. Thus, the part of the response curve that is above the point X on Fig. 6 is of no use at all; in other words, we will have to confine ourselves to that part of the curve below the first zero. Now this comes at the point where the wavelength in the tape equals the length of the gap, and this gives an indication of what we can do to see that the up and down portion of the response curve is at higher frequencies than those which we want to record. There are two ways in which the problem can be tackled. One is to increase the speed of the tape. If this is done, it increases

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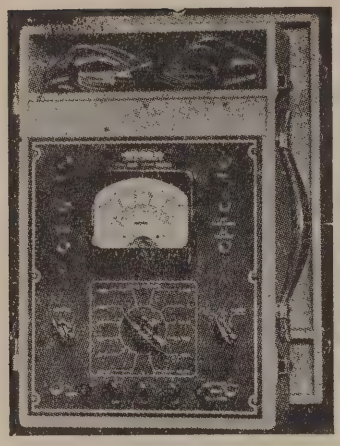

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the wavelength in the tape for all frequencies, in proportion to the speed increase. For example, in the case worked out, 100 c/sec. had a wavelength of 0.075 in. If the tape speed were doubled, making it 15 in./sec., the wavelength would also be doubled and would become 0.15 in. If this is done, therefore, the frequency at which the first zero comes will also be doubled. Unfortunately, speeding up the tape is a solution that we do not want to resort to unless absolutely necessary, since this will limit the recording time that can be had with a given length of tape.

The other method is fairly obvious, and is to decrease the width of the gap. If the gap is halved, the effect is the same as that of doubling the tape speed. It is for this reason that very small gaps are used in recording heads. And although past a certain frequency the response of the record will always exhibit the peak-and-valley feature, all we have to do is to make the gap small enough, and the speed fast enough, for the first point of zero response to be rather higher in frequency than the highest we wish to record.

(To be continued.)

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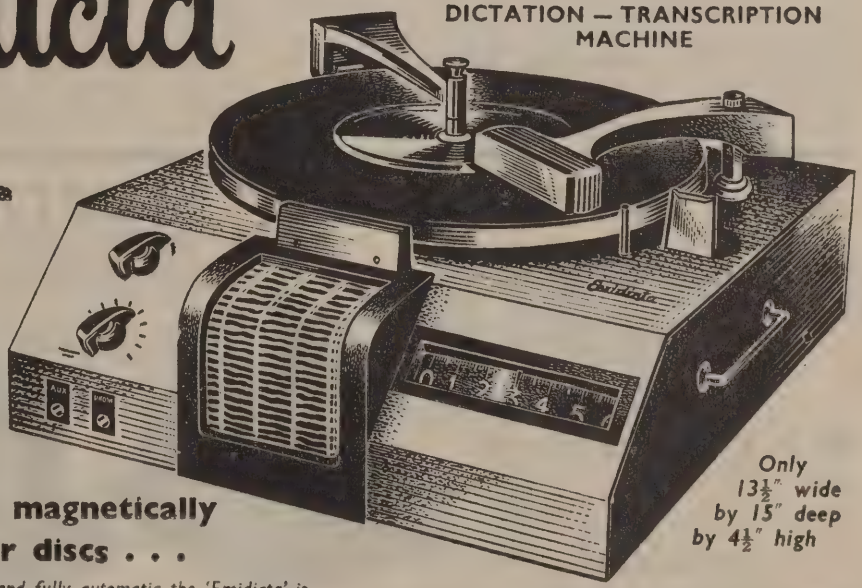

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N.Z.E.I. Newsletter

(Continued from Page 32.)

ment with the equipment themselves, this invitation being accepted by the majority of those present. The meeting closed at 9.30 p.m.

Dunedin: A well attended meeting in Dunedin presided over by Mr. William L. Shiel viewed a series of films covering amongst others matters—

(1) "Communications. News and Views." This film demonstrated the development of the telephone.
(2) "Stairway to Heaven." The discovery of the principle of the telescope and its subsequent improvements resulting in the giant telescope of today, as used in astronomical observations, made this a film of unusual interest.
(3) "Music in the Sky." A screening of Radio Broadcasting starring the famous American singer John Charles Thomas.
(4) Westinghouse presented the next film in technicolour dealing with the discovery, development, and manufacture of fluorescent lighting equipment. This film was of exceptional interest, as the advantages of fluorescent lighting are now being widely appreciated in this country. The amazing complexity of the many intricate machines and processes necessary being shown in great detail. As an example of modern American methods of manufacture this film is to be commended.

The arrangements for this show were in the capable hands of Messrs. Andersen and McGregor to whom a vote of thanks was passed.

Wellington: Wellington has adopted a most progressive policy and now has available for members a Branch Library. Written requests for books should be addressed to—

Mr. J. D. McCormick, Hon. Branch Librarian, N.Z.E.I., 17 Aglionby Street, Lower Hutt.

Additions to the Library since 31st July, 1950:

Electronic Measuring, Vol. 2, No. 12, and Vol. 3, No. 1.
Philips Experimenter, No. 29.
Electronic Application Bulletin, Vol. X, No. 12, and Vol. 11, Nos. 1, 2, 3.
Radiotronics, January to June, 1949.

Radio and Electronics. The Branch is indebted to Mr. W. D. Foster for his generous donation of back copies of this magazine. He has donated all issues from Vol. 1, No. 1 (April, 1946) to Vol. 4. No. 4 (June 1949) except one issue, Vol. 1, No. 9 (December 1946). This means that the Branch Library has all issues of this magazine except Vol. 1, No. 9. The gratitude of the Branch is also extended to Mr. D. L. Rushworth for his gift of all copies of *A.W.A. Review* except Vol. 1, No. 1 and a large number of back copies of *The General Radio Experimenter.*

The branch is also indebted to Mr. R. J. Dippy, B.Sc., A.M.I.E.E., who recently gave a most interesting address on "Gee," that important navigational aid of the Second World War. Mr. Dippy originated the principle of Gee, and was responsible for the whole of its development. The main body of Mr. Dippy's talk was concerned with the extremely interesting circuitry of Gee, but the speaker entertained the branch with many tales illustrating its operational use and the manner in which the Services exploited its possibilities to the full. It is not generally known that ships equipped with Gee were enabled by it to prepare for the landing on D-Day in a way which would hardly have been possible without it.

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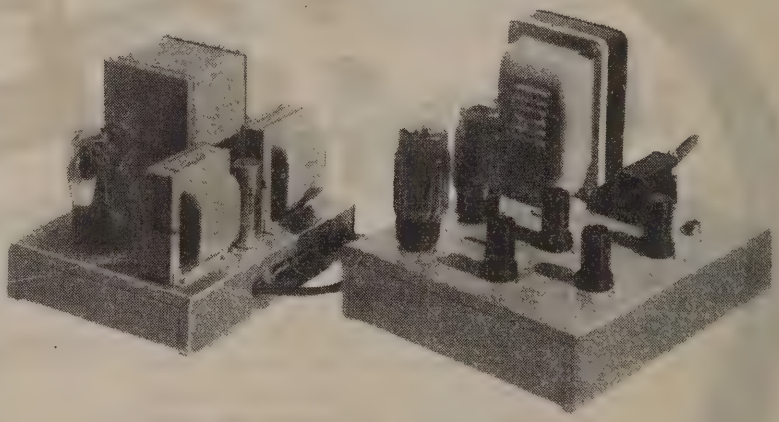

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Philips Experimenter

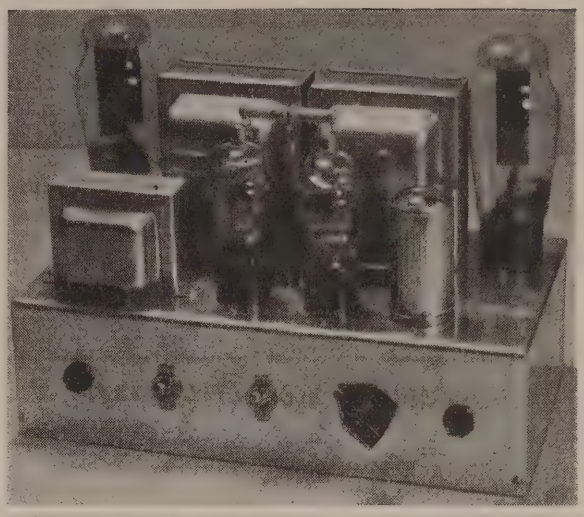
(Continued from Page 25.)

dropping resistor, reduces this to 250v. at the screen pins. The large screen bypass condenser becomes necessary in order to keep the valves operating properly as pentodes, with this set-up.

Note that individual 50k. grid stopper resistors have been used with the modulators. If these are omitted, the stage will oscillate at some supersonic frequency. It was not found necessary to use plate stoppers in the original model, but should high-frequency oscillation persist in spite of the use of grid stoppers, small plate stoppers of, say, 100 ohms each should be tried.

When a single power supply is used for both modulators and modulated stage, only one modulation choke is needed, but this has to have the required inductance with the total current flowing through it. Thus, although two small chokes might look expensive in parts, they are probably cheaper than a single 150 ma. choke with enough inductance at full current drain to allow a reasonable low-frequency response.

This does not alter the basic relations of Heising modulation, but simply isolates the power supplies from each other, while passing the modulator power through to the mod. amp. by capacity coupling. In the diagram, these chokes are labelled L, as are the smoothing chokes, to indicate that all four are of the same type. There is not room on the power supply chassis for both modulation chokes, so that the second one is mounted in the free space on the R.F. chassis, as indicated in the circuit diagram. The value of the coupling condenser C can be varied within quite wide



limits according to the kind of low-frequency response desired. With chokes of 20 henries, and a condenser of 0.5 μf., the low response rolls off from approximately 300 c/sec., which is a desirable characteristic for gear intended for speech frequencies only.

The voltage amplifier stages are obtained in a single ECC35, with sections cascaded. This gives enough gain for any microphone likely to be used in the ham shack, and a good deal more than enough for some of the higher level mikes in use today. If a high-output microphone is to be used, the first stage can be omitted. In

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the prototype, it was found that with a common cathode resistor for the two stages, as drawn, the speech amplifier as a whole oscillated at one particular setting of the gain control. However, this can be cured, should it occur, by using separate cathode resistors and bypass condensers for the two stages of the ECC35. When this change is made, the cathode resistors should be 2500 ohms for each half.

The photograph shows the lay-out of the main parts on the power supply/modulator chassis. This is slightly larger than the R.F. chassis, being 10½ in. x 6 in. x 3 in. The switches S_1 and S_2 can be seen on the chassis front, as can the gain control knob and the packs for audio input and output. The shielded valve is the ECC35, and the jack next to it is the input jack.

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A PRACTICAL BEGINNERS' COURSE

PART 42: VALVES IN PARALLEL

The amplifier that was described in the last instalment of this Course is very similar to one portion of almost all full-sized radio sets except for the fact that these do not use battery valves, but indirectly-heated A.C. valves, so-called. However, amplifiers consisting of a simple two-valve arrangement are not always used. Sometimes, it is required to have more power output, and therefore more sound from the speaker than a single valve can give. In this case there are three ways in which more power output can be obtained. The first, and obvious one, is to use a much larger valve, which will need greater heater current and more plate current, and very often more plate voltage too. For this reason, a larger valve type is not very often used for the purpose. It is often cheaper and simpler to use two small valves rather than one big one, because this time it is not necessary to have a greater plate voltage, but only a greater plate current. One of the most often used valves for ordinary sets is the 6V6. This can give about 4 watts output, but this is often considered to be not enough for large console sets. If we use two 6V6s, however, we can get 8 watts output, at the cost of increasing the current drawn by the set from the power supply, but with the same voltages as for one tube. The question we are to discuss in this issue is, "How can two valves be connected in order to give more power output?" There are two ways. The simplest is to connect them in *parallel*. As readers can guess, this is simply a matter of inserting an extra valve socket, and connecting corresponding valve electrodes in parallel. That is to say, the control grids are connected together, and so are the plate, screens, and cathodes. Having done this, we use the two valves, so connected, just as if they were one large valve, and for all practical purposes, this is what they are. For this reason, one often sees circuit diagrams where two valves in parallel are represented by a single valve symbol, labelled as "2 x 6V6." Sometimes, however, the two valve symbols are drawn in, together with the connections that join them in parallel.

On yet other occasions, the two valves are drawn, and extra resistors are inserted in the circuit, in such a way as to appear to the uninitiated to serve no useful purpose. That is to say, instead of the two plate pins of the valves being connected together directly, they are joined through small resistors, which may be as low as 100 ohms in value. The junction of the resistors then goes to the same part of the circuit as would the plate of a single valve, namely, to one end of the output transformer's primary winding. The same thing may be done with the screens, and even with the control grids. This makes the circuit look quite complicated. These resistors are called "stoppers," and classified according to the element in whose circuit they are connected. Grid stoppers are most often used, and have the purpose of preventing the two valves from acting as a generator of unwanted oscillations. If you are copying a circuit, do not leave out these resistors on any account, because they are not inserted if they are not needed, and the result of their omission may be that the amplifier does not work at all, or only with much distortion, and little power output.

(To be Continued.)

Dynamic Noise Suppressor

(Continued from Page 5.)

from any pick-up. The curves, and the figures quoted above, all apply to the codition where the suppression control is set at maximum. If the control is set to give less suppression, this simply prevents the gates from closing so much, so that in the absence of a control signal, the response is wider than is given by the curve labelled 1.1 volts.

With the gates fully open, the high-frequency response extends to 6000 c/sec. for 3 db. down, and to below 20 c/sec. It would appear, therefore, that the unit would hardly be satisfactory for use with a high-quality amplifier, because a high-frequency response up to 6000 c/sec. is hardly good enough for getting the best out of modern recordings, speakers, and pick-ups. It should not be condemned out of hand, however, since the circuit is stated by the designer to be suitable only for inexpensive gramophones, which cannot be described as high-fidelity or anything like it. Nor would we go so far as to say that it is not worth building by the serious experimenter. *It does work.* Indeed, one of our chief criticisms of its performance is that it works so obviously. That is to say, if, on a very noisy record, the suppression is made effective enough to give a noticeable measure of noise reduction, then it is very apparent to the ear that there is something "different" about the reproduction. On a good record, in which there is little surface noise, it is debatable whether the noise suppressor is of any advantage at all. Of course, one cannot dogmatize about things like this, but the writer's impression of the suppressor when used on good recordings, was that he preferred to put up with what little surface noise was present rather than lose the high-frequency response entailed by the use of the suppressor.

Again it must be emphasized that the above is not a criticism of the *system*, but only of this particular application of it. We have not yet heard a Scott noise suppressor designed for use with a high-fidelity system, and it is highly likely that should we do so, the answer would be quite a different one. However, this is a very interesting development, and one that would repay a considerable amount of experiment. For example, if the existing circuit were modified so as to give a flat response up to 10 kc/sec. or better, when the gates were fully open, it seems probable that our main objection might be removed.

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(Continued from Page 39.)

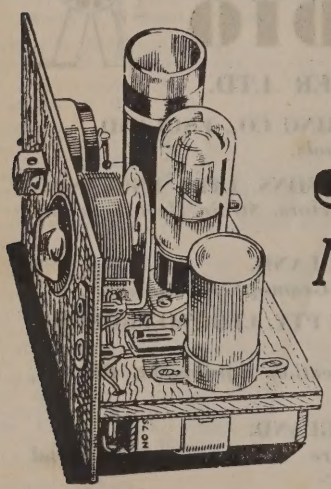
where the input for the noise amplifier is picked off *before* the stage in which the noise is cancelled, this objection does not apply, and the explanation given really does apply. With the change in input connection, as used here, the mechanism must be rather different. It is thought that the cancellation of the noise does not take place in V_1 itself, but in the succeeding stages, because we have one of those vicious circles where, if cancellation were completed in V_1, there would be no noise output to be applied to V_{10}. In practice, the passage through the noise suppressor chain cannot be instantaneous, even if the actual time taken is exceedingly short, say of the order of a fraction of a microsecond. Thus, a pulse appearing at the output of V_1 which causes the noise rectifier to work, will be followed after this very small delay by another pulse, in the reverse sense, so that as far as the *following* valves are concerned, the net result is two low-amplitude pulses, instead of one high-amplitude pulse. Moreover, the two small pulses are of such exceedingly small duration that their audible effect is zero.

In the past, the proper Lamb circuit has been subject to much criticism. It has been incorporated in some high-priced commercial receivers, and complaints have been heard that it does not work properly. In order to see just what happened, we connected the circuit just as in the original Lamb arrangement, with the input of V_{10} obtained from the input side of V_1. The system was found to work, in that pulses *were* delivered by the noise rectifier, but was also found not to work, in that these pulses were not of large enough amplitude to effect proper suppression of V_1. By changing the circuit to the one illustrated, however, a considerably increased amplitude was made available at the grid of V_{10}, so that the output pulses from the rectifier were now large enough to cut off the plate current of V_1 quite easily. At all events, there is no doubt about the noise suppressing qualities of the circuit as given, and interesting as the theory of it may be, the main thing is that it is effective!

THE SERIES DIODE NOISE-SUPPRESSOR CIRCUIT

Apart from the fact that the polarity of the diode detector has been changed, the left-hand section of V_3 is a conventional detector circuit. Similarly, the right-hand half of V_3 acts as a conventional series diode noise-suppressor. There is one difference from normal here too, but this is simply due to the reversal of the detector polarity which makes it necessary to reverse the usual polarity for the series diode too. Otherwise, the circuit is quite normal, and requires no comment. The output of V_3 is taken to one pole of the change-over switch for going from 455 to 100 kc/sec., Sw_{2A} on the diagram, and it can be seen that R_{36}, the audio volume control, can be switched from the output of V_3 to the output of V_7, which is the 100 kc/sec detector.

(To be Continued.)



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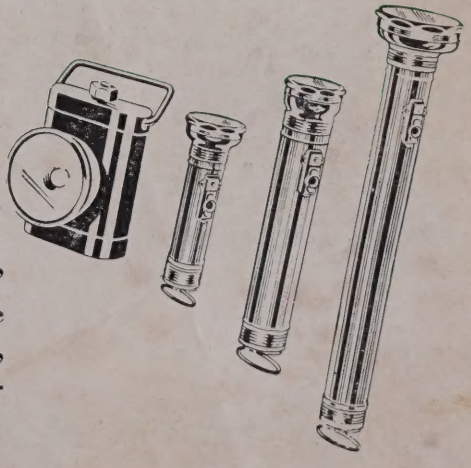

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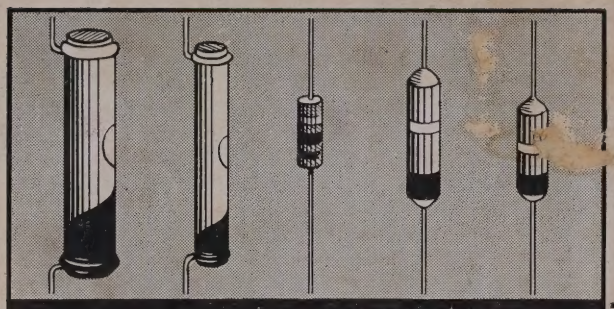

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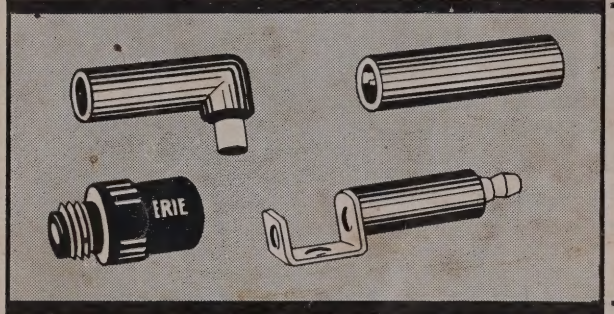

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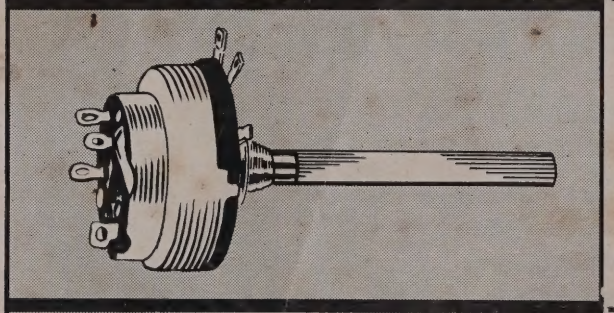

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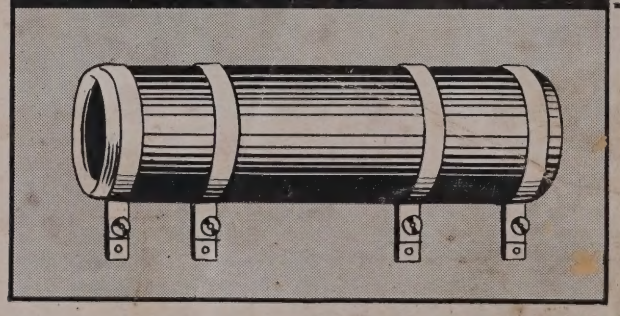

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